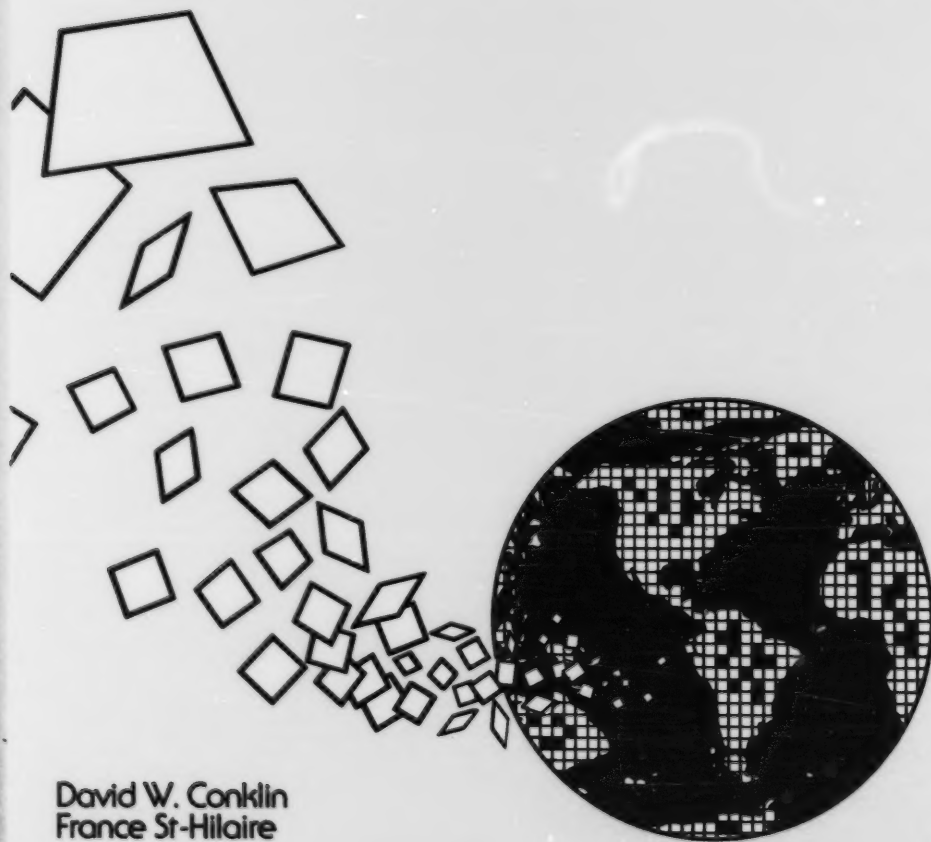
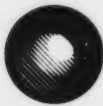


Canadian High-Tech IN A NEW WORLD ECONOMY: A Case Study of Information Technology



David W. Conklin
France St-Hilaire



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Foreword

Recognizing a serious deficiency in currently available information on trade in Canada's information technology industry, the Information Technology Association of Canada, formerly the Canadian Business Equipment Manufacturers Association, initiated discussions with the Institute for Research on Public Policy which led to this study. It is based on research undertaken in 1986-1987 by the Institute, with financial support from the federal government's Department of Regional Industrial Expansion and the Information Technology Association of Canada. The project involved the direct participation of a large number of ITAC's individual member companies, and built upon previous work by the Institute in the trade and technology area. The purpose of the project was to develop a broad overview of Canadian high-tech activities that incorporates the many diverse aspects of this subject and that suggests insights concerning the direction and scope of Canadian high-technology industries as well as appropriate public policy for these economic activities. The objective has not been to construct a specialized technical analysis, but rather to produce a book for the interested non-specialist who wishes to understand the rapid and significant changes in Canadian production activities that are commonly referred to as "high-tech."

Within this broad perspective, the example of the information technology sector proved helpful. The OECD has predicted that only a small proportion of potential applications in this field have been achieved thus far. Also, because information technologies have

applications in a broad range of industries, they will have a significant impact on both the composition of employment and the structure of the economy. It is hoped that this study will contribute significantly to general understanding of the realities of production and trade in this important industry.

Even with this focus on information technology, this study reviews a vast canvas. While such a survey inevitably can touch only the highlights, it illustrates the range and diversity of policy issues relevant to Canada's role in a new, changing, and dramatically more competitive world economy.

In brief, this document sets out a simple thesis: Canada's trade in high technology products or services must inevitably move toward a more open structure, since a favourable "high tech balance" cannot be achieved simply by restrictions on imports; despite this, a stronger competitive position in sophisticated equipment and services can be engineered for the Canadian economy—it is not necessary to accept passively whatever role current market conditions seem to dish out; given the nature of the industry, however, traditional instruments for industrial policy are increasingly called into question and subject to restrictions under international agreements on trade and non-tariff barriers; but in any case the more fundamental determinants of an enduring comparative advantage in knowledge-based equipment and services are likely to emerge from social as well as private investments in research, education, skills, and training. One can, in other words, create the knowledge base and technological expertise which represent the critical factors of production in a high tech world. But to do so will require more effective organization of our education and research activities, and probably greater cooperation amongst the business, government, and university enterprises engaged in the development and dissemination of new knowledge and new skills.

One of the more immediate results of this project was to highlight possible problems of methodology in Canada's trade statistics. It is interesting to note that Statistics Canada has recently announced a new high technology classification which has the effect of reducing Canada's measured deficit in high technology trade from \$12.5 billion to \$5.8 billion in 1985. This result emphasizes the importance of the classification methodology in statistical work dealing with "high tech trade" or the balance of technological payments, a significant finding of the research work on which this book is based.

Appropriate public policies can facilitate Canadian adjustment to changes in international competition. This book suggests that many nations will look increasingly to education and research as the cornerstones of a new high-tech strategy, and it explores the issues that may be raised by an increased Canadian reliance upon education

and research to assist in creative economic adjustment by a small open country in the new world economy. In the aftermath of the National Forum on Post-secondary Education, and in light of the turbulent outlook for bilateral and multilateral trade negotiations, these questions will require much reflection and debate.

Rod Dobell
President

December 1987

Avant-propos

La grande insuffisance des données disponibles à l'heure actuelle relativement au commerce dans l'industrie de la technologie de l'information au Canada a poussé l'Association canadienne de la technologie de l'information, anciennement appelée l'Association canadienne des fabricants d'équipement commercial, à engager avec l'Institut de recherches politiques des discussions qui ont abouti à cette étude. Celle-ci est basée sur des recherches menées en 1986-87 par l'Institut, grâce à un appui financier du ministère de l'Expansion régionale industrielle (gouvernement fédéral) et de l'Association canadienne de la technologie de l'information. Le projet, qui impliquait la participation directe d'un grand nombre de compagnies membres de l'ACTI à titre individuel, avait pour base les travaux préalablement accomplis par l'Institut dans le domaine du commerce et de la technologie. Le but du projet était de faire un tour d'horizon de l'état actuel de la haute technologie au Canada qui tienne compte de toutes les facettes de ce sujet et qui permette d'avoir un aperçu de la direction et de l'étendue des industries canadiennes de haute technologie, ainsi que des politiques publiques relatives à ces activités économiques. L'objectif n'était pas de réaliser une analyse technique spécialisée, mais plutôt de produire un ouvrage destiné aux non-spécialistes qui s'intéressent à la question et qui aimeraient comprendre les importantes et rapides transformations qui affectent la production au Canada, de ce qu'on appelle communément "la haute technologie".

Dans cette vaste perspective, l'exemple du secteur de la technologie de l'information s'est avéré utile. Selon l'OCDE, seule une faible proportion des applications possibles dans ce domaine auraient été réalisées jusqu'ici. De plus, du fait que les technologies de l'information sont applicables à des industries variées, elles auront un impact important sur la composition des emplois et la structure de l'économie. Il faut espérer que cette étude contribuera de façon importante à une compréhension générale des faits concernant la production et le commerce relativement à cette importante industrie.

Bien que l'étude ait porté tout spécialement sur la technologie de l'information, elle traite néanmoins d'un vaste domaine. Son amplitude implique qu'elle ne puisse illustrer que les faits saillants, et pourtant elle fait état de l'étendue et de la diversité des questions politiques relatives au rôle du Canada au sein d'une économie mondiale en transformation et qui devient de plus en plus concurrentielle.

En résumé, ce document avance une thèse bien simple : dans le domaine des produits ou des services de haute technologie, le commerce canadien doit inévitablement progresser en vue d'une structure plus ouverte, puisque l'"équilibre en haute technologie" ne sera jamais atteint uniquement en imposant des restrictions sur les importations; malgré ce fait, l'économie canadienne pourrait devenir plus concurrentielle en matière de production d'équipement et de services sophistiqués. Le Canada n'a pas à accepter passivement le rôle que les conditions actuelles du marché voudraient lui faire jouer. Cependant, étant donné la nature de l'industrie, la politique industrielle traditionnelle est de plus en plus remise en question et sujette à des restrictions causées par les accords internationaux sur les barrières commerciales et non-tarifaires. En tout cas, il est probable que les déterminants les plus fondamentaux qui permettront au Canada de jouir d'un avantage comparatif durable en matière d'équipement et de services à base de connaissances proviendront vraisemblablement d'investissements sociaux et privés dans la recherche, l'enseignement, les techniques et la formation professionnelle. En d'autres termes, il est possible de créer la base de connaissances et l'expertise technologique qui sont les facteurs critiques de la production dans le monde de haute technologie où nous vivons actuellement. Pour arriver à ces fins, il faudrait toutefois organiser plus efficacement notre système d'enseignement et de recherche, et probablement avoir une meilleure coopération entre tous les organismes (monde des affaires, gouvernement et universités) impliqués dans le développement et la dissémination des nouvelles connaissances et des nouvelles techniques.

L'un des résultats les plus immédiats de ce projet était de mettre en lumière certains problèmes potentiels de méthodologie au niveau

des statistiques commerciales du Canada. Il est intéressant de remarquer que Statistique Canada a récemment annoncé l'établissement d'une nouvelle classification pour la haute technologie, qui a eu pour effet de réduire le déficit mesuré du commerce de haute technologie au Canada : de 12,5 milliards de dollars, celui-ci est passé à 5,8 milliards de dollars en 1985. Ce résultat souligne l'importance de la méthodologie de classification employée pour les travaux de statistiques qui ont trait au "commerce de la haute technologie", ou à la balance des paiements technologiques. Ceci est un des résultats majeurs du travail de recherche sur lequel ce livre est basé.

Des politiques appropriées pourraient aider le Canada à s'ajuster aux transformations au niveau de la concurrence internationale. Les auteurs de ce livre sont d'avis que de nombreux pays vont dorénavant compter de plus en plus sur l'enseignement et la recherche, qui deviendront les pierres angulaires du développement des stratégies de nouvelles hautes technologies. Ils se demandent ce qui arriverait si le Canada décidait de s'appuyer davantage sur l'enseignement et la recherche pour aider un petit pays ouvert au libre-échange à s'ajuster d'une manière créative à la nouvelle économie mondiale. Après les échanges du Colloque national sur l'enseignement post-secondaire et dans la perspective de négociations commerciales bilatérales et multilatérales mouvementées, ces questions devront encore faire l'objet d'une réflexion plus profonde et être longuement débattues.

Rod Dobell
Président

Décembre 1987

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This study is based on the results of a research project which was commissioned by the Department of Regional Industrial Expansion and the Information Technology Association of Canada (formerly CBEMA), who supported the production of an earlier overview document "Canada's Trade in High Technology Products: A Case Study of Business Equipment." We are also appreciative of the cooperation we received from a number of ITAC members who agreed to be interviewed and who completed a questionnaire. The insights they provided were particularly helpful in identifying the many conceptual and statistical difficulties with current indicators of Canadian competitiveness in high technology.

Our research was carried out over the course of 18 months and the manuscript underwent several rounds of re-writing. We wish to convey our deep appreciation to the many individuals who took the time to go through the lengthy drafts and offered us many constructive comments and helpful suggestions. They include John Whalley, Pierre-Paul Proulx, Rodrigue Tremblay, Kristian Palda, Humphrey Stead, and Peter Cornell.

We also want to thank John Henderson, Mitch Kowalski, and John Mitsopulos for their research assistance and valuable contributions. In particular, John Henderson's statistical overview of Canada's information technology sector and the report prepared by John Mitsopulos on Japan were important contributions to the project.

Finally, we would like to express our thanks for the secretarial assistance received from the Department of Economics, University of Western Ontario.

As always, the analysis and conclusions presented here are those of the authors alone and do not necessarily reflect the views of the Government of Canada or the Information Technology Association of Canada.

Executive Summary

Chapter I presents an overview of the volume, indicating the broad themes that dominate the discussion, and it explains the division of the volume into parts A, B, and C.

Part A

Chapter II begins with a study of Canada's competitiveness. Evidence suggests that large segments of the Canadian manufacturing sector are not internationally competitive. Our poor performance has been attributed to low productivity. It has led many to emphasize the need for greater rationalization and specialization in Canadian manufacturing fostered by freer international trade as a way of overcoming this handicap. Suggestions have also been made that Canada has failed to reallocate resources from low-growth to high-growth, knowledge-intensive sectors.

Chapter III extends the discussion of Chapter II to consider Canadian competitiveness as shown by our production and use of new technology. A wide variety of literature and data are brought to bear on this subject, and add further perspective to the debate. There is significant evidence that technology is an important factor explaining productivity growth. In many instances, the indirect effects of technology that occur, for example, through input purchases, are more significant than the direct effects. This emphasizes the importance of

the linkages between producers of new technology and their customers, who use goods embodying that new technology.

As a source of technology, Canada is a small player, creating only 0.3 per cent of the world's patented inventions and undertaking significantly less research and development than other countries in the Organization for Economic Cooperation and Development (OECD). Canada is, therefore, largely dependent on foreign sources for the technology it requires. In fact, Canada may be one of the world's most important recipients of foreign technology. This role as a recipient or user of technology is crucial because research shows that innovations originate for the most part in a relatively few countries (United States, Japan, Germany, France, Great Britain) and in a relatively small number of industries. Observers also emphasize the strong interlinkages in this sector: the industries that produce technology are also the major users of technology from other sources. This observation and other findings confirm the importance of research and development as a factor in the diffusion process. Industries that undertake research and development activities are more likely to be aware of which technologies to acquire, and are more likely to adapt these for their own purposes. Other factors such as the firm's size and foreign ownership are also directly related to early adoption of new technology. Studies suggest that Canada's tariff-protected market has been a major factor inhibiting diffusion because of the resulting small scale and short production runs. On the other hand, foreign ownership and the intracorporate transactions it involves have been associated with relatively shorter technology transfer lags for Canada.

Chapter IV examines the particular characteristics of the information technology sector and discusses the likely patterns of development and economic prospects in this area. A statistical overview of the Canadian information technology sector is also provided in order to present a general indication of its relative size and performance.

It has been estimated that as much as 80 per cent of current and medium-term future technological advances will be IT-based. Evidence suggests that at present, only 10 to 20 per cent of potential applications in information technology have been achieved and that a much larger impact can be expected in the near future. The wide applications will not only affect the production and process structures of industrial activity, but will also have an impact on the composition of employment. Information technology will become such an essential element of technological progress in most economic activities, the potential gains from IT use cannot be ignored. Furthermore, the skill intensity, the operation costs, and the economies of scale associated with the manufacture of IT-based capital goods suggest that only

certain countries will be able to operate effectively in this area on a large scale. It is reasonable, therefore, for Canada to expect to be the innovator and manufacturer of only a small portion of the world's latest products and production processes. In order to introduce modern technology, Canadian firms will have to import the necessary requirements. Hence, a negative balance of trade in these products may not reflect a failure but rather may reflect the creative application of the world's latest technology.

The data suggest that a relatively small number of multinationals, through intra-firm transactions, significantly impact the industrial and market structures of information technology sectors. These and other questions concerning the role of multinational enterprises (MNEs) in Canada are addressed in Chapter V. To a major extent, Canadian production and trade in the information technology sector occur within multinational enterprises. In order to understand international patterns of production and trade, it is necessary to understand how MNEs function. Foreign-controlled subsidiaries account for about half of Canadian manufacturing assets. However, in most high-tech industries, this percentage is well over half. Looking at corporations that sell office machines and equipment one sees an overwhelming U.S. dominance, with only a few exceptions, Northern Telecom Ltd. being the most notable.

A substantial body of literature has considered theoretical explanations for the existence of MNEs and has analyzed the MNE corporate decision process related to investment, production, and trade. Chapter V surveys this literature, and it emphasizes the role of MNEs in transferring technological advances achieved in other nations to the subsidiaries operating in Canada. An additional concern is that international trade that occurs within MNEs is different than arm's-length transactions. MNEs can establish their own internal transfer prices. Because transfer pricing can be used to redistribute profits and expenditures among affiliates not related to the transactions at hand, it may result in distortions in the statistics concerning investment, production, and trade. The chapter also looks at the importance of transfer price manipulations as a tax minimizing mechanism.

Global economic trends have led to a new approach to corporate decision making with the MNE. Traditionally, all strategic decisions were once made in the head office, with subsidiaries operating as branch plants and producing a wide range of products for the domestic market. The subsidiary had short, high-cost production runs. Increasingly, however, the head office is a marketplace for evaluating production proposals from subsidiaries that bid against each other for global mandates or specialized missions. The MNE has its own internal marketplace. Each subsidiary produces for the world market,

enjoying economies of scale as well as benefiting from the global firm's specific advantages. In this process, the MNE has achieved much of the gains from freer trade even without new political agreements.

A major issue in the debate over Canada's competitiveness in high technology is that of determining what are the appropriate indicators to gauge this situation. Chapter VI focuses on the conceptual and statistical problems related to this issue. We raise serious questions about the appropriateness of using the high-tech trade deficit as a measure of Canada's international competitiveness. There is no universally accepted definition of what constitutes a high-tech product. Different countries and international agencies use different classification methodologies.

An examination of Statistics Canada's trade data concerning the information technology industry reveals shortcomings in the collection and classification of data, and provides alternative interpretations of the data. Statistics Canada has indicated that it will adopt a new classification scheme based on the methodology of the Organization for Economic Cooperation and Development. In calculating high-tech trade data, Statistics Canada will use a new list of high-tech products which is more up-to-date and more narrowly defined. With this new high-tech classification, estimates of Canada's high-tech trade deficit are much smaller than previous data suggested.

Nevertheless, in analyzing the trade flows of this sector, special consideration should be given to the impact of high-tech imports on the productivity of Canada's traditional economic activities. Technological advances are occurring throughout the Canadian economy, and many of these advances require the importation of high-tech machinery and equipment. From this perspective, we see that a growth in Canada's high-tech trade deficit may be necessary in order to increase the international competitiveness of traditional economic activities.

This suggests the need for more informative indicators that, for example, may use input-output analysis techniques to identify the technological intensiveness of products. Ideally, these indicators would reflect the technology embodied in the inputs as well as the use of high-tech services, sophisticated capital equipment and skilled labour as factors associated with the production of these products. It is possible that a better indicator would restrict the value of high-tech trade to the value of embodied technology.

Parts B and C

Parts B and C deal with government policies that may stimulate Canadian high technology and enhance competitiveness. Chapter VII

provides an overview of how some traditional industrial policies can be considered in this context. A central concern in Part B is that these traditional industrial policies have become the subject of international negotiations. Previous political agreements have attempted to constrain their use and current Canada-U.S. and forthcoming GATT negotiations will seek to limit the use of such policies even further. What will be the likely impact on Canadian high-technology—and on the information technology sector in particular—of these new international agreements to create freer trade?

A rapidly growing body of literature suggests that freer trade will create a better economic future for Canada than would an increase in government intervention through traditional protectionist policies. Our examination of tariffs, subsidies, government procurement, and regulations, provides little hope that more government intervention in these areas would be helpful. Throughout the Canadian economy, improvements in efficiency will require imports of high-tech machinery and equipment; and barriers to these imports would retard the adoption of new processes. Government regulations that protect domestic firms from foreign competition can mean higher prices for domestic consumers, both for individuals and for other firms. These regulations can also foster inefficiency and higher costs within the protected companies—an inefficiency that freer international competition would not allow. Furthermore, special programs for government assistance to industry are too often inadequately targeted and a waste of taxpayers' money. For all these reasons, the evidence suggests that Canadians have more to fear from new high-tech protectionist strategies than from freer trade. This conclusion is not meant to dismiss all high-tech policies. Rather it argues that protectionist government intervention cannot be the basis for strengthening our international competitiveness. In Part C, we consider education and research as a more positive and creative means for Canadian governments to stimulate high technology and enhance our competitiveness.

In Part B, Chapter VIII presents a brief history of GATT tariff negotiations, indicating the current tariff levels. For computer manufacturers, current Canada-U.S. rates of 3.9 per cent for hardware and nil for software are not a major determinant of trade patterns. Nevertheless, since most Canadian purchases are imported, tariff reduction would directly reduce selling prices. This could increase sales, accelerating the Canadian adoption of technological advances. A lower U.S. tariff would also directly affect the profitability of Canadian computer firms since most of their production now goes to the U.S. market.

Telecommunications and factory equipment generally face higher tariffs, so new tariff agreements could require substantial adjustment by manufacturers. Tariff reductions could facilitate international specialization, and global mandates.

Chapter IX considers subsidies and possible agreements to limit their use. Subsidies that are aimed directly at education and research are not dealt with extensively here, but rather are treated separately in Part C. Education and research subsidies have not yet become the focus of international agreements. Other countries have not sought to limit their use, because education and research subsidies do not directly alter market prices.

Subsidies alter the price ratios that would result in a free competitive marketplace. The recipients of subsidies may offer their goods and services for sale at lower prices than they would receive in the absence of subsidies. Foreign-based corporations see these lower prices as unfair competition. Hence, international trade negotiations have come to focus on these subsidy programs as a trade distortion that should be limited by formal international agreements. The last GATT round of negotiations resulted in subsidy codes for particular types of financial assistance. Current Canada-U.S. negotiations are also dealing with this subject. Meanwhile, the United States has taken a firm position that it should impose special countervailing duties if any of its corporations are being hurt by foreign subsidies.

Governments can use their procurement policies to assist domestic high-tech firms, and this is the subject of Chapter X. A 1984 Canadian task force report on Federal Policies and Programs for Technology Development strongly advocated a more extensive use of procurement policies for this purpose. The annual purchases by the federal government of over \$300 million of information technology goods and services indicate that procurement policies can play a significant role in this sector. We describe current Canadian federal and provincial practices, as well as those of European countries and the United States. Finally, the Tokyo round of GATT negotiations resulted in an agreement to limit the use of procurement policies that favour domestic firms. We consider the degree to which this code limits Canadian governments in their domestic preferences. As a practical matter, we suggest that public servants and politicians seem able to avoid the provisions of any procurement agreement. For the information technology sector, the growth of solution selling involves a wide variety of products and services, and this introduces differences among competing bids. Faced with bids that are not strictly comparable, the purchasing government can devise any number of excuses for favouring domestic firms.

Chapter XI examines the issue of regulation in the context of high-tech policies. Considerable attention is devoted to the Foreign

Investment Review Agency (FIRA) because of the significance of MNEs in the information technology sector, and because one of FIRA's key criteria for accepting foreign investment was "the effect of the acquisition or establishment on productivity, industrial efficiency, technological development, product innovation, and product variety in Canada." The founders and supporters of FIRA believed that the regulation of foreign investment could enhance Canadian technology and international competitiveness. The advantages and shortcomings of this type of industrial policy are presented.

With the abolition of FIRA, the most significant regulations affecting Canada's information technology sector relate to telecommunications. Throughout the world, governments have been extending telecommunication regulations. Several objectives underlie this trend: the enhancement of culture and cultural sovereignty; the provision of domestic employment; and the protection of privacy. These objectives also underlie current Canadian regulations. In the case of provincial government regulations, local employment appears to be a prime concern. These regulations can involve considerable expense and inefficiency, however. Canadian citizens have to weigh these costs against the advantages of such regulations. Apart from the domestic concern about costs are the foreign concerns about accessibility to the Canadian market. It is clear that forthcoming international negotiations will deal extensively with these issues. The drive toward free trade may automatically bring with it a significant degree of deregulation.

The protection of intellectual property includes legislation concerning patents, trademarks, industrial designs, copyrights, and trade secrets. Chapter XII considers this subject in the context of information technology. Three sets of recent changes receive particular attention. First, the nature and content of intellectual property have been changing in several important respects, including new mechanisms for reproduction and transmission, greater research collaboration among many individuals and groups, and wider applicability of many ideas and processes. These have complicated the development of appropriate legislation. Second, public funds are playing an increasing role in financing research and development, blurring the division of ownership between private interests and society as a whole. Third, the world economy has become more closely integrated, with the result that the creation of intellectual property in one country may be readily copied in other nations. Consequently, no society alone can protect intellectual property. Rather, the protection of intellectual property can be achieved only through international agreements. By signing these agreements, Canada provides the citizens of other national signatories the opportunity to register their

ownership of intellectual property in Canada, just as if they were citizens of Canada.

Part C deals with education and research as the basis of a new high-tech strategy. Obviously, governments throughout the world have long recognized the appropriateness of allocating public funds to education and research. In Chapter XIII we consider the rationale for education and research policies in the context of high-tech and international competitiveness. Greater job mobility means that the corporation will not invest in its employees' education as much as would be socially optimal because of the risk of losing the employee and the educational investment. Yet the ability of a society as a whole to attract desirable types of high-tech investment and well-paying jobs will depend increasingly on the qualifications of that society's labour force.

Rapid and significant changes in products and production technology mean that employee skills and education quickly become outmoded. Retraining will become increasingly necessary if employees are to be able to shift into new occupations resulting from new products and processes. Otherwise, rising unemployment will place a great burden on the society as a whole.

Chapter XIII also discusses the ways in which modern technology dictates the meshing of education and research policies. In this context, it discusses the role of the general education as opposed to specialized education. It emphasizes a new role for the corporation based on the need to relate education with job requirements, to retrain employees continually, and to link university research with commercial applicability. We explore this university-corporate nexus through a discussion of a number of Canadian and U.S. experiences.

Throughout this book, most of our commentary and illustrations are based on Canadian and U.S. experiences. Within Canada's information technology sector, nearly all of the MNEs are based in Canada and the United States. Yet the new world economy is being dramatically affected by developments in other nations, particularly in Japan. Consequently, we felt it important to devote a chapter to Japanese experiences in education and research. Chapter XIV emphasizes the central role that education and research policies have come to play as part of Japanese high-tech strategy. In particular, Japan is relying heavily on these policies as a mechanism for facilitating adjustment.

Chapter XV examines the Canadian record in education and research. At first glance, the statistics create a favourable impression. Over the 25-year period 1960-1985, enrolment of full-time university students rose from 114,000 to over 460,000. Over the 1965-1985 period, part-time enrolment rose from 65,000 to over 275,000. Over the 1970-1985 period, full-time college enrolment rose

from 166,000 to 330,000. Advances on the research side were nearly as dramatic. Over the period 1971-1986, gross domestic expenditures on R&D in constant dollars (1981) nearly doubled, rising from \$2.7 billion to over \$5 billion.

Nevertheless, a number of disquieting elements blot this Canadian record. Over the 1979-1985 period, operating grants to universities declined by over 20 per cent on a per student basis. Significant variations exist across provinces; per student operating grants are particularly low in Nova Scotia, Prince Edward Island, and New Brunswick. Capital expenditures on university facilities have declined dramatically over the past 15 years. The number of earned Ph.D degrees climbed until 1972, but have remained constant since then. Ph.D enrolment in natural and applied sciences fell 25 per cent over the decade of the 1970s. While Canadian research and development has climbed, nevertheless, Canada's relative R&D input ranks far below other OECD nations.

A number of federal and provincial programs allocate public funds to corporate R&D activities, and Chapter XV describes some of these. Of special interest are new programs that seek to foster joint corporate-university research. Meanwhile, the programs that allocate public funds to the retraining of employees are placing a greater emphasis on retraining within corporations rather than in formal education institutions.

In summarizing the many issues and analyses of this book, Chapter XVI focuses on three perspectives: integration, change, and knowledge. These three concepts are closely related. Integration is the result of a variety of changes, and is itself the cause of further changes. Knowledge involves an understanding of changes—past, present, and future—together with insights as to how to use this understanding in economic activities. Change includes adjustment to the new circumstances created by various kinds of integration and by advances in knowledge.

This book describes a new world economy in which a number of historical barriers and divisions are disappearing very quickly. The economic integration of separate political entities is clearly a significant development. Journalistic commentaries emphasize the new political agreements that, in a variety of ways, tend to erase political boundaries. However, this book emphasizes economic forces rather than political agreements. Throughout the world we are witnessing the more rapid and wider diffusion of product and process technologies and the globalization of competition.

A key role in this economic integration is being played by MNEs. Apart from trade in agricultural products, a very large portion of trade occurs within corporations. The networks of parents and

subsidiaries have become mechanisms for the rapid transfer of production technology as well as goods and services.

Our study of computers has led us to realize that product lines that were once manufactured and sold separately are now being integrated as a package sale. The creation of solutions also involves a greater emphasis on creative personal knowledge, and this means that the sale includes services such as software and consulting as well as physical goods. This integration of production and sales activities has important implications for barriers to trade and for new political agreements to reduce those barriers. Integration is also occurring in the activities between customers and suppliers. Increasingly, solution selling is a tailor-made package developed in accordance with the particular needs of the customer. A final area of integration that also has important ramifications concerns linkages between governments, educational institutions, and corporations.

The various types of integration have developed as responses to particular changes in the economic and technological environment. Integration itself is leading to additional changes. For the information technology sector, change is an ever-present feature. For many information technology firms, sales and profitability depend on their ability to create and sell new solutions. In this sense, many information technology firms sell change. This perspective emphasizes the significance of the diffusion of new technology, with individual modifications to suit the needs of each customer. An important aspect of change is that, for a number of reasons, it tends to be cumulative. An entrepreneurial culture can develop in a certain geographical area or within a certain population group. These geographical aspects of change may tend to exacerbate regional economic disparities.

The importance of technological change draws attention to the question of organizational processes that can facilitate this change. For instance, processes that directly involve each employee in group decisions about improvements in quality and new production technology may be effective. This is of particular importance when we consider the need for innovation within government administrations. Increasingly, the relationships and processes that may facilitate technological change will be of public concern, since they will be a major determinant of a nation's international competitiveness.

The creation and application of new knowledge is the central driving force within both integration and change. We will present a broad view of knowledge that includes education, retraining and research. This broad view emphasizes not only technical knowledge concerning products and production processes, but also the understanding of human nature in regard to such matters as employment motivation and consumer purchases. In our new world of

integration and change, knowledge in both sciences and humanities are important determinants of a society's international competitiveness.

Canada, in our new world economy, will experience constant change. To retain the best jobs and highest wages, we must continually re-educate and retrain our work force. Corporations will continually find their sales mix changing, with new products and services being combined to create new solutions. Education and research will enable these corporations to retain a leading position in the technological race. From this perspective, education and research can be seen as the central mechanism for creative adjustment in an ever-changing world economy. They will form the cornerstones of future Canadian competitiveness.

Abrégé

Le chapitre premier présente une vue d'ensemble du volume. Il en indique les principaux thèmes et justifie sa division en trois sections principales : A, B et C.

Section A

Le chapitre II débute par une étude sur la compétitivité du Canada. Il apparaît que d'importants secteurs manufacturiers canadiens ne sont pas concurrentiels sur le plan international. Cette situation serait due à une productivité médiocre et nombreux sont ceux qui pensent qu'il est urgent d'arriver à une meilleure rationalisation et à une meilleure spécialisation de l'industrie canadienne, au moyen d'une plus grande libéralisation du commerce international. On y souligne également que le Canada n'a pas réussi à réassigner ses ressources des secteurs à faible croissance à ceux en pleine expansion qui font appel à de hautes connaissances.

Le chapitre III continue sur la lancée du chapitre II et examine la compétitivité des Canadiens, telle qu'elle apparaît à travers la production et l'emploi des nouvelles technologies. Une grande variété d'études et de données sont envisagées et viennent ajouter une dimension supplémentaire au débat. Il devient évident que la technologie joue un rôle important dans l'augmentation de la productivité. Dans beaucoup de cas, les effets indirects de la technologie, survenant par exemple au cours d'achats d'introduction,

sont plus significatifs que les effets directs. Cela met en valeur les liens qui existent entre les producteurs de nouvelle technologie et leurs clients qui utilisent des biens de production incorporant cette nouvelle technologie.

Comme source de technologie, le Canada joue un rôle peu important, puisqu'il ne compte que pour 0,3 pour cent dans l'établissement des brevets d'invention sur le plan mondial, et qu'il consacre beaucoup moins d'efforts à la recherche et au développement que les autres pays membres de l'Organisation de coopération et de développement économique (O.C.D.E.). Il dépend pas conséquent largement des autres pays pour satisfaire ses besoins en technologie. En fait, le Canada est sans doute l'un des principaux utilisateurs de la technologie étrangère. Cette situation de fait est cruciale car les statistiques montrent que les inventions se font en général dans un nombre de pays relativement peu élevé (Etats-Unis, Japon, Allemagne, France, Grande-Bretagne) et au sein d'industries relativement peu nombreuses. On souligne également les interconnexions puissantes qui existent dans ce secteur : les industries productrices de technologie sont aussi les principales utilisatrices de technologies provenant d'autres sources. Cette observation, ainsi que d'autres découvertes, confirment l'importance de la recherche et du développement comme facteur dans le processus de diffusion. Les industries qui conduisent des activités de recherche et de développement sont plus à même de choisir la technologie qui leur est nécessaire et plus aptes à l'adapter à leurs propres besoins. D'autres facteurs, tels que la taille de l'entreprise et le caractère international de ses propriétaires, sont aussi directement en rapport avec l'adoption précoce d'une nouvelle technologie. Les études montrent que la protection du marché canadien par des tarifs douaniers a été une cause majeure dans le ralentissement de la diffusion technologique, du fait d'une faible production portant sur une petite échelle. D'un autre côté, les investissements étrangers, ainsi que les transactions entre filiales qu'ils supposent, semblent être la cause d'une diminution relative dans les décalages de transfert technologique que l'on observe au Canada.

Le chapitre IV examine les caractéristiques propres au secteur de la technologie de l'information et traite des schémas de développement probable dans ce secteur, ainsi que de ses perspectives économiques. Il présente également des statistiques générales pertinentes à ce domaine, afin de nous informer sur son importance relative et sur ses activités.

On estime que jusqu'à 80 pour cent des progrès technologiques actuels et à moyen terme prendront place dans le secteur de la technologie de l'information (T.I.). Les données actuelles indiquent que seulement 10 à 20 pour cent du potentiel de la T.I. a été employé et

qu'il faut s'attendre à un beaucoup plus grand rôle de cette technologie dans l'avenir. L'utilisation généralisée de la T.I. affectera non seulement les méthodes de production et les systèmes organisationnels de l'industrie, mais elle aura également ses conséquences sur la composition de la main-d'oeuvre. La technologie de l'information est appelée à devenir un élément essentiel du progrès technologique dans la plupart des activités économiques, et les gains potentiels qui peuvent en résulter ne doivent pas être ignorés. En outre, la spécialisation, les coûts de fonctionnement et les économies d'échelle inhérents à la fabrication des biens d'équipement à base de T.I. indiquent que seuls certains pays seront capables de réussir sur une large échelle, dans ce domaine. Le Canada doit donc raisonnablement s'attendre à n'être le créateur et le fabricant que d'une faible portion des produits les plus récents, et à n'avoir qu'un rôle limité dans les processus de production. Pour s'adapter à la nouvelle technologie, les firmes canadiennes devront importer les éléments nécessaires. Par conséquent, une balance commerciale négative dans ces produits ne sera donc pas un signe d'échec mais reflétera plutôt une faculté d'adaptation à la technologie mondiale la plus récente.

Les données indiquent qu'un nombre relativement faible de multinationales, par l'entremise de transactions internes, exercent une influence significative sur les structures industrielles et de marché des secteurs de la technologie de l'information. Le chapitre V traite de cet aspect et des autres questions relatives au rôle des multinationales dans l'économie canadienne. La production et le commerce canadiens, dans le secteur de la technologie de l'information, s'effectuent, dans une large mesure, à l'intérieur des multinationales. Pour comprendre les structures internationales de production et de commercialisation, il est indispensable de voir comment fonctionnent les multinationales. Les filiales sous contrôle étranger comptent pour environ la moitié du potentiel de fabrication au Canada. Toutefois, ce pourcentage est bien supérieur à la moitié dans les industries de haute technologie. Si l'on considère les corporations qui vendent des machines et du matériel de bureau, on constate que le marché est largement dominé par les États-Unis, à quelques exceptions près, notamment Northern Telecom Ltd.

Un grand nombre d'études ont été consacrées à expliquer théoriquement l'existence de multinationales et à analyser leur processus décisionnel relativement aux investissements, à la production et au commerce. Le chapitre V examine ces études et souligne le rôle des multinationales dans le transfert, à leurs filiales au Canada, des améliorations technologiques mises au point dans d'autres pays. Un autre point à noter est que les échanges commerciaux opérés à l'intérieur d'une entreprise multinationale

diffèrent de ceux effectués au cours de transactions libres. Les multinationales peuvent fixer leurs propres prix de transfert. Et puisque la fixation des prix de transfert peut être aménagée de façon à redistribuer des bénéfices et des charges entre des filiales qui ne sont pas directement concernées par les transactions en question, il peut en résulter des distorsions dans les statistiques relativement aux investissements, à la production et au commerce. Ce chapitre comprend aussi une évaluation de l'importance des modifications que peuvent subir les prix de transfert à des fins de réduction fiscale.

Les tendances économiques globales ont amené les multinationales à revoir leurs procédures de prises de décision. Traditionnellement, toutes les décisions stratégiques étaient prises au siège social, alors que les filiales fonctionnaient comme des succursales et fabriquaient une vaste gamme de produits destinés au marché local. Les filiales avaient ainsi une production de faible ampleur qui était par conséquent coûteuse. Le siège social des multinationales est en passe de devenir le lieu où s'évaluent les propositions de production des filiales, lesquelles se font concurrence pour l'obtention d'opérations globales ou de missions spécialisées. La multinationale a donc son propre marché interne. Chaque filiale produit pour le marché mondial, bénéficiant ainsi des économies d'échelle ainsi que de tous les avantages spécifiques généraux dont jouit la multinationale. Dans cette évolution, l'entreprise multinationale a réussi à obtenir un grand nombre des avantages liés à une plus grande liberté des échanges, sans avoir à attendre la signature de nouveaux accords politiques.

Une des questions majeures dans le débat au sujet de la compétitivité du Canada en matière de haute technologie est de déterminer quels sont les indicateurs appropriés pour évaluer la situation. Le chapitre VI traite principalement des problèmes conceptuels et statistiques en rapport avec cette question. Nous soulevons de sérieuses objections quant à la pertinence d'utiliser le déficit commercial en matière de haute technologie pour évaluer le degré de compétitivité internationale du Canada. Il n'existe pas de définition universellement admise de ce qui constitue un produit de haute technologie. Différents pays et organismes internationaux emploient différentes méthodes de classification.

Un examen des données commerciales relevées par Statistique Canada, dans le secteur de l'industrie de la technologie de l'information, fait apparaître des déficiences dans la collection et la classification des données et donne sujet à des interprétations diverses. Statistique Canada a indiqué qu'il allait adopter un nouveau système de classement, basé sur celui utilisé par l'O.C.D.E. Dans sa prise en compte des données, Statistique Canada emploiera une liste plus à jour de produits de haute technologie et partira d'une

définition plus stricte. Avec cette nouvelle classification, les estimations du déficit commercial en matière de haute technologie sont beaucoup moins importantes qu'avec l'ancien système d'évaluation.

Néanmoins, dans l'analyse des mouvements commerciaux de ce secteur, on devrait considérer plus particulièrement l'impact des importations de haute technologie sur la productivité des activités économiques traditionnelles du Canada. Des progrès technologiques se manifestent dans toute l'économie canadienne, et beaucoup d'entre eux nécessitent l'importation de machinerie et de matériel de haute technologie. C'est donc de ce point de vue qu'on peut dire qu'une augmentation du déficit commercial du Canada en matière de haute technologie peut être nécessaire pour accroître la compétitivité internationale des activités économiques traditionnelles.

Cela entraîne la nécessité d'avoir davantage d'indicateurs susceptibles de donner des renseignements plus précis, par exemple en utilisant des techniques d'analyse prenant en considération la valeur ajoutée et le rendement, pour identifier l'intensité technologique des produits. Idéalement, ces indicateurs reflèteraient la technologie contenue dans la valeur ajoutée aussi bien que l'utilisation des services de haute technologie, le matériel sophistiqué investi, aussi bien que la main d'œuvre spécialisée, en tant que facteurs nécessaires à la création de ces produits. Il est possible qu'un meilleur indicateur parvienne à ramener la valeur du commerce de la haute technologie à celle de la technologie incorporée.

Sections B et C

Les sections B et C traitent des politiques gouvernementales susceptibles de stimuler la haute technologie canadienne et d'augmenter sa compétitivité. Le chapitre VII fournit une vue d'ensemble sur la manière dont certaines politiques industrielles traditionnelles peuvent être envisagées dans ce contexte. La section B traite principalement de l'évolution qui fait que les politiques industrielles traditionnelles sont devenues l'objet de négociations internationales. Des accords politiques antérieurs ont été signés pour essayer de réglementer leur mise en œuvre; les négociations actuelles entre le Canada et les États-Unis, ainsi que les négociations futures dans le cadre du GATT, tenteront de limiter encore plus le rôle de ces politiques industrielles particulières. Quelles conséquences ces nouveaux accords internationaux, tendant vers une plus grande liberté des échanges, vont-ils vraisemblablement avoir sur la haute technologie canadienne, et plus particulièrement sur le secteur de la technologie de l'information?

Des études de plus en plus nombreuses sur cette question laissent entendre qu'un système d'échanges plus libre procurera au Canada un avenir économique meilleur que celui que pourrait lui donner une politique interventionniste gouvernementale traditionnelle. Notre examen des tarifs, des subventions, des approvisionnements gouvernementaux et des réglementations offre peu d'espoir de voir de telles mesures procurer un avantage quelconque dans le sens de l'amélioration recherchée. Pour augmenter les rendements de l'économie canadienne dans son ensemble, il faudra importer de la machinerie et du matériel de haute technologie, et les mesures protectionnistes contre ces importations ne pourraient que retarder la modernisation. Les réglementations gouvernementales visant à protéger les entreprises nationales contre la concurrence étrangère peuvent entraîner des prix plus élevés pour les consommateurs, au niveau du particulier ou de l'entreprise. Elles peuvent aussi favoriser l'inefficacité et de plus hauts coûts à l'intérieur des compagnies protégées, conséquences qu'un contexte de concurrence internationale plus libre permettrait d'éviter. Les programmes gouvernementaux spéciaux d'aide à l'industrie sont en outre trop souvent mal conçus et gaspillent l'argent des contribuables. Pour toutes ces raisons, il semble évident que les Canadiens ont beaucoup plus à craindre de nouvelles stratégies protectionnistes en matière de haute technologie que d'une politique d'échanges plus libérale. Ce qui ne veut pas dire que toutes les politiques concernant la haute technologie soient à rejeter, mais plutôt qu'une intervention gouvernementale protectionniste ne peut servir de base de départ pour le renforcement de notre compétitivité internationale. Dans la section C, nous considérons que l'éducation et la recherche constituent des moyens plus positifs et plus efficaces, qui permettent aux gouvernements canadiens de stimuler la haute technologie et de renforcer notre compétitivité.

Dans la section B, le chapitre VIII présente un bref historique des négociations tarifaires du GATT, avec une indication des niveaux tarifaires en cours. Pour les fabricants d'ordinateurs, le taux actuel Canada-U.S. est de 3,9 pour cent sur les appareils et nul pour les logiciels, ce qui n'influence pas d'une manière importante les schémas des échanges. Pourtant, une réduction de tarif pourrait directement abaisser les prix de vente, puisque la plupart des produits achetés par les Canadiens sont importés. Il en résulterait une augmentation dans les ventes et l'adoption accélérée par les Canadiens des dernières nouveautés technologiques. Un tarif américain plus bas affecterait aussi directement le rendement des compagnies d'ordinateurs canadiennes, puisque la plus grande partie de leur production est maintenant destinée au marché américain.

Le matériel de télécommunications et d'usine est généralement assujéti à des tarifs plus élevés, et de nouveaux accords tarifaires pourraient entraîner d'importantes mesures d'adaptation de la part des fabricants. Des réductions tarifaires pourraient favoriser une spécialisation internationale et des productions concentrées.

Le chapitre IX examine les subventions et les accords possibles pour en limiter l'usage. Les subventions qui visent l'éducation et la recherche ne sont pas traitées d'une manière approfondie dans ce chapitre, elles sont examinées séparément dans la section C. Les subventions d'éducation et de recherche n'ont pas encore fait l'objet d'accords internationaux. Les autres pays n'ont pas essayé d'en limiter l'usage, parce que ces subventions n'influencent pas directement les prix du marché.

Les subventions modifient les rapports de prix tels que ceux-ci apparaîtraient dans un marché de libre concurrence. Les bénéficiaires de subventions peuvent offrir leurs produits et services à des prix inférieurs à ceux qu'ils devraient demander en l'absence de subventions. Les corporations installées à l'étranger considèrent que ces subventions constituent une concurrence déloyale. Il en résulte que, dans les négociations commerciales internationales, on en vient à voir dans ces programmes de subventions une source possible de distorsion des mécanismes commerciaux qui devrait être réglementée par des accords internationaux officiels. La dernière série de négociations du GATT a abouti à la mise sur pied de codes de subventions pour certains types particuliers d'aide financière. Les négociations actuelles entre le Canada et les Etats-Unis s'occupent également de ce problème. Les Etats-Unis ont par ailleurs adopté une attitude ferme à l'égard de cette question : ils imposeront des droits compensatoires chaque fois que l'une de leurs corporations aura à souffrir les effets de subventions étrangères.

Le chapitre X est consacré à l'étude des politiques d'approvisionnement que les gouvernements créent pour venir en aide à leurs entreprises de haute technologie. Le rapport de 1984 d'un groupe d'étude canadien sur les politiques et programmes fédéraux pour le développement de la technologie plaide fortement en faveur d'une utilisation plus étendue des politiques d'approvisionnement à cette fin. Les achats annuels par le gouvernement fédéral de plus de 300 millions de dollars de produits et de services relatifs à la technologie de l'information sont la preuve qu'une politique d'approvisionnement peut jouer un rôle déterminant dans ce secteur. Nous décrivons les pratiques courantes canadiennes, à l'échelon fédéral et provincial, ainsi que celles des pays européens et des Etats-Unis. Finalement, la série des négociations du GATT de Tokyo a abouti à un accord visant à limiter l'emploi de politiques d'approvisionnement, quand celles-ci favorisent les entreprises

domestiques. Nous examinons dans quelle mesure ce code limite la liberté des gouvernements canadiens dans leur décision en faveur d'entreprises domestiques. D'un point de vue pratique, il nous semble que les fonctionnaires et les politiciens parviennent à éviter les clauses imposées par les accords sur les approvisionnements. Pour le secteur de la technologie de l'information, la croissance de la vente de solutions met en jeu une grande variété de produits et de services, et cela amène des différences parmi les soumissions en concurrence. Placé devant des soumissions qui ne sont pas strictement comparables, le gouvernement acheteur peut trouver toutes sortes d'excuses pour favoriser les firmes locales.

Le chapitre XI examine le problème de la réglementation dans le contexte des politiques en matière de haute technologie. L'Agence de révision des investissements étrangers (ARIE) y fait l'objet d'une attention particulière, du fait de l'importance des multinationales dans le secteur de la technologie de l'information, et parce que l'un des critères de base de l'ARIE pour l'admission d'un investissement étranger était "l'effet de cette acquisition ou de cet établissement sur la productivité, sur l'efficacité industrielle, sur le développement technologique, sur l'innovation et la variété dans les produits au Canada." Les créateurs et partisans de cette agence croyaient que la réglementation des investissements étrangers pouvait renforcer la technologie canadienne et sa compétitivité sur le plan international. Le chapitre XI discute des avantages et des inconvénients d'une telle politique industrielle.

Après la dissolution de l'Agence de révision des investissements étrangers, la réglementation la plus significative affectant le secteur de la technologie de l'information du Canada touche au domaine des télécommunications. Les gouvernements à travers le monde ont mis au point des réglementations concernant les télécommunications. Plusieurs objectifs se trouvent à l'origine de cette tendance : le renforcement de la culture et de la souveraineté culturelle, le besoin d'assurer l'emploi des citoyens, la protection de la vie privée. Ces objectifs se retrouvent à la base des réglementations canadiennes actuelles. Dans le cas de la réglementation provinciale, l'emploi de la main d'oeuvre locale semble être la préoccupation majeure. Cette réglementation peut cependant entraîner des dépenses considérables, ainsi qu'une certaine inefficacité, et les citoyens canadiens doivent comparer ces coûts par rapport aux avantages procurés par la réglementation. De plus, mis à part le problème des coûts domestiques, il faut également se préoccuper de l'accessibilité des autres pays du monde au marché canadien. Il est évident que les négociations internationales à venir traiteront de ces questions d'une manière approfondie. La tendance vers le libre-échange peut amener automatiquement un degré important de déréglementation.

La protection de la propriété intellectuelle comprend la législation relative aux brevets, aux marques de fabrique, aux modèles industriels, aux copyrights et aux secrets commerciaux. Le chapitre XII examine cette question dans le contexte de la technologie de l'information. Trois séries de changements récents sont plus particulièrement étudiées. Premièrement, la nature et le contenu de la propriété intellectuelle ont subi d'importants changements, à plusieurs points de vue, par exemple du fait de nouveaux procédés de reproduction et de transmission, du fait d'une plus grande collaboration dans la recherche entre particuliers et entre groupes, ou du fait d'une plus large utilisation de nombreuses idées et méthodes. Ces changements ont rendu plus difficile l'élaboration d'une législation appropriée. Deuxièmement, les fonds publics jouent un rôle croissant dans le financement de la recherche et du développement, rendant plus difficile la distinction entre la propriété privée et la propriété publique. Troisièmement, l'économie mondiale est devenue beaucoup plus intégrée, ce qui entraîne le risque de voir la création de la propriété intellectuelle d'un pays promptement recopiée dans les autres pays. La protection de la propriété intellectuelle ne peut être assurée par un seul pays; elle ne peut être acquise que par des accords internationaux. En participant à ces accords, le Canada offre aux citoyens des autres pays signataires la possibilité d'inscrire au Canada leurs droits à la propriété intellectuelle, de la même façon que les citoyens canadiens.

La section C traite de l'éducation et de la recherche considérées comme base de la nouvelle stratégie en matière de haute technologie. Il est évident que les gouvernements du monde entier ont depuis longtemps reconnu la nécessité d'allouer des fonds publics pour l'éducation et la recherche. Dans le chapitre XIII, nous considérons les raisons à l'origine des politiques en matière d'éducation et de recherche, dans le contexte de la haute technologie et de la compétitivité internationale. Une plus grande mobilité dans le travail signifie que les corporations n'investiront pas dans la formation de leurs employés autant que cela serait socialement désirable, à cause du risque qui existe de perdre l'employé et donc l'investissement en éducation. Pourtant, la capacité d'une société donnée à attirer des catégories désirables d'investissement en haute technologie et d'emplois bien rémunérés va de plus en plus dépendre des qualifications de la main d'oeuvre de cette société.

Les changements continuels et importants dans les produits et dans la technologie de production rendent les connaissances pratiques et théoriques des employés rapidement démodées. Le recyclage deviendra de plus en plus nécessaire pour permettre l'adaptation du personnel à de nouvelles occupations conformes aux nouveaux

produits et procédés. Sans cela, l'accroissement du chômage deviendra un pesant fardeau pour la société tout entière.

Le chapitre XIII examine également la manière dont la technologie moderne a rendu interdépendantes l'éducation et les politiques de recherche. Dans ce contexte, nous traitons du rôle de l'éducation générale par rapport à l'éducation spécialisée, et nous soulignons le rôle nouveau joué par les corporations, basé sur le besoin de mettre en rapport l'éducation et les exigences d'emploi, d'avoir continuellement à former les employés et de lier la recherche universitaire à ses applications commerciales. Nous explorons la connexion entre les universités et les corporations à partir d'un certain nombre d'expériences canadiennes et américaines.

D'un bout de ce livre à l'autre, la plupart de nos commentaires et de nos exemples ont pour objet des expériences canadiennes et américaines. Presque toutes les multinationales du secteur de la technologie de l'information du Canada sont basées au Canada ou aux Etats-Unis, et pourtant la nouvelle économie mondiale est considérablement affectée par les développements qui se produisent dans les autres pays, particulièrement par ceux du Japon. En conséquence, nous avons jugé important de consacrer un chapitre aux expériences du Japon dans le domaine de l'éducation et de la recherche. Le chapitre XIV souligne le rôle primordial que l'éducation et la recherche ont été amenées à jouer dans la stratégie de haute technologie au Japon, et en particulier, le fait que le Japon compte fortement sur ces activités pour faciliter l'adaptation au progrès.

Le chapitre XV examine l'état de la situation au Canada en matière d'éducation et de recherche. Au premier coup d'oeil, les statistiques donnent une impression favorable. Au cours de la période de 25 ans allant de 1960 à 1985, les inscriptions dans les universités d'étudiants à plein temps sont passées de 114.000 à plus de 460.000. De 1965 à 1985, les inscriptions d'étudiants à temps partiel ont augmenté de 65.000 à 275.000, et de 1970 à 1985, les inscriptions dans les collèges d'étudiants à plein temps sont passées de 166.000 à 330.000. Du côté de la recherche, les progrès étaient presque du même ordre: de 1971 à 1986, les dépenses domestiques brutes pour la recherche et le développement en dollars constants (1981) ont presque doublé, passant de 2,7 milliards à plus de 5 milliards de dollars.

Pourtant, un certain nombre de points noirs viennent assombrir le tableau canadien. De 1979 à 1985, les subventions de fonctionnement accordées aux universités pour chaque étudiant inscrit ont diminué de plus de 20 pour cent. Il existe également des variations importantes d'une province à l'autre; les subventions accordées pour chaque étudiant inscrit sont particulièrement basses en Nouvelle-Ecosse, à l'Ile-du-Prince-Edouard et au Nouveau-Brunswick. Les dépenses en capital pour les universités ont baissé

considérablement au cours des 15 dernières années. Le nombre de doctorats décernés a augmenté jusqu'en 1972 mais n'a pas changé depuis cette date. Les inscriptions aux programmes de doctorat en sciences naturelles et en sciences appliquées a baissé de 25 pour cent pendant la décennie des années 70. Alors que la recherche et le développement au Canada ont augmenté, la contribution relative en recherche et développement est considérablement inférieure à celle des autres pays membres de l'O.C.D.E.

Un certain nombre de programmes fédéraux et provinciaux permettent l'allocation de fonds publics aux entreprises pour la subvention de leurs activités de recherche et de développement; certains de ces programmes sont décrits au chapitre XV. On remarquera en particulier quelques nouveaux programmes qui tendent à favoriser la collaboration de recherche entre universités et corporations. D'un autre côté, les programmes qui allouent des fonds publics pour la formation permanente d'employés donnent une plus grande importance à la formation permanente au sein des entreprises qu'à la formation fournie par les établissements d'enseignement.

Pour apporter une conclusion aux nombreuses questions et analyses présentées dans ce livre, le chapitre XVI se concentre sur trois perspectives : l'intégration, les changements et les connaissances. Ces trois concepts sont étroitement liés. L'intégration est le résultat d'une variété de changements, et elle est également à l'origine d'autres changements supplémentaires. Les connaissances impliquent une bonne compréhension des changements (passé, présent et futur) ainsi qu'une idée générale de la manière dont ces connaissances peuvent être appliquées aux activités économiques. Les changements impliquent l'ajustement aux nouvelles circonstances créées par les différentes sortes d'intégration et par les progrès en matière de connaissances.

Ce livre fait une description de la nouvelle économie mondiale, au sein de laquelle un certain nombre de barrières et de divisions historiques sont rapidement en train de disparaître. Il est clair que l'intégration économique d'entités politiques indépendantes les unes des autres est un développement important. Les commentaires journalistiques soulignent les nouveaux accords politiques qui, de plusieurs manières, tendent à effacer les frontières politiques. Toutefois, ce livre met en valeur les forces économiques plutôt que les accords politiques. Nous sommes les témoins d'une diffusion rapide et étendue des produits et des technologies de transformation, ainsi que d'une généralisation de la compétition, à l'échelle mondiale.

Les multinationales jouent un rôle clé dans cette intégration économique. A part le commerce de produits agricoles, une très grande partie du commerce se fait entre entreprises. Les réseaux constitués par les corporations mères et leurs filiales sont devenus des

mécanismes assurant le transfert rapide de la technologie de production ainsi que celui des biens et services.

Notre étude du secteur de l'informatique nous a permis de nous rendre compte que des lignes de produits, préalablement fabriquées et vendues séparément, sont maintenant intégrées en transactions globales (fabrication et vente). La création de solutions implique également qu'une plus grande importance est accordée aux connaissances créatives personnelles, ce qui implique que la vente comprend non seulement du matériel, mais encore des services tels que des logiciels et des rencontres avec des conseillers techniques. Cette intégration de la production et de la vente a des implications importantes sur les barrières commerciales et sur les nouveaux accords politiques visant à réduire ces barrières. L'intégration se produit également dans les activités entre clients et fournisseurs. La vente de solutions, préparées sur mesure selon les besoins du client, devient de plus en plus populaire. Un dernier aspect de l'intégration, qui a lui aussi des ramifications importantes, est celui des rapports entre les gouvernements, les établissements d'enseignement et les entreprises.

Les différents types d'intégration ont vu le jour pour répondre à des changements particuliers de l'environnement économique et technologique. L'intégration elle-même conduit à des changements supplémentaires. Dans le secteur de la technologie de l'information, le changement est un élément constamment présent. Pour de nombreuses firmes de technologies de l'information, le volume des ventes et des profits dépend de leur capacité de créer et de vendre de nouvelles solutions. Dans ce sens, beaucoup de firmes de technologies de l'information vendent des changements. Cette perspective souligne l'importance de la diffusion de la nouvelle technologie, avec des variantes individuelles pour répondre aux besoins particuliers de chaque client. Un des aspects importants des changements est que, pour un certain nombre de raisons, ils ont tendance à être cumulatifs. Un noyau d'entrepreneurs peut ainsi se développer dans une certaine région ou dans un groupe de population particulier. Cette concentration géographique des changements a tendance à exacerber les disparités économiques régionales.

L'importance des changements technologiques attire l'attention sur la question des procédés d'organisation qui peuvent faciliter ces changements. Par exemple, les procédés selon lesquels chaque employé participe aux décisions de groupe relatives aux améliorations de la qualité et aux nouvelles technologies de production, peuvent être efficaces. Ceci est particulièrement important lorsqu'on considère le besoin d'innovation dans l'administration gouvernementale. Les rapports et les procédés qui visent à faciliter les changements technologiques concerneront de plus en plus le public, dans la mesure

où ils constitueront un des déterminants majeurs de la compétitivité du Canada à l'échelle internationale.

La création et l'application de nouvelles connaissances est la force motrice principale de l'intégration et des changements. Nous présentons une vue générale des connaissances, englobant l'éducation, la formation permanente et la recherche. Cette vue d'ensemble met l'accent non seulement sur les connaissances techniques relatives aux produits et aux procédés de production, mais encore sur la compréhension de la nature humaine en face de considérations telles que la motivation dans l'emploi et les achats des consommateurs. Dans notre nouveau monde d'intégration et de changements, les connaissances en sciences et en humanités sont des déterminants importants de la compétitivité internationale d'une société.

Avec la nouvelle économie mondiale, le Canada est appelé à subir des changements constants. Afin de garder les emplois les meilleurs et les salaires les plus élevés, nous devons rééduquer et recycler continuellement nos travailleurs. Les entreprises vont s'apercevoir que leurs ventes ne cessent d'évoluer avec de nouveaux produits et services qui se combinent pour produire de nouvelles solutions, et c'est l'éducation et la recherche qui leur permettront de rester en première position dans la course à la technologie. L'éducation et la recherche peuvent donc être considérées comme le mécanisme central permettant de s'adapter dynamiquement à une économie mondiale en perpétuelle évolution. Elles restent essentielles à la compétitivité future du Canada.

Chapter I

Overview

Introduction

Our research began as an examination of the computer industry, but as it progressed, we realized that the dividing line between computers and many other high-tech industries has been quickly disappearing. Computer companies today see themselves as selling wide-ranging "solutions" to the problems of other corporations. These solutions involve numerous activities centred on hardware, software, consulting and servicing. Where there was once a fairly clear distinction between the products of industries such as office equipment, telecommunications, microelectronics and factory machinery, new developments in electronics and computer technology have resulted in a tremendous expansion of the field of applications for such technologies and a gradual merging of the activities of these sectors. How should we describe and categorize this new economic sector? The phrase "information technology" has become widely used. Information technology (IT) deals with all aspects of the accumulation, analysis, transfer, and use of information, defined broadly to include words as well as data.

In Part A, we examine Canada's information technology sector. Two broad themes dominate our discussion. First, the Canadian situation must be understood in the context of the global economy. Canadian investment, employment, production, and technological change are intimately linked with activities in other countries. International trade, international investment, and the multinational

enterprise are central in our discussion of Canada's information technology sector. Second, the information technology sector is interesting and important not only in its own right, but also as a means of introducing technological progress throughout Canada's traditional economic activities. In the latter role, the information technology sector is now a key element in Canada's overall growth and prosperity. With the adoption of new types of information technology, Canada's traditional goods and services can become high-tech themselves. Many regard information technology as an economically strategic good in that one's access to the best available technology will determine the level of one's economic competitiveness. The lack of important inputs could cripple industries that would otherwise be competitive. This perspective leads us to criticize the standard categorization of goods and services into high-tech, medium-tech, and low-tech; and it leads us to criticize the standard calculations and interpretations of Canada's high-tech trade deficit.

These two themes provide interesting and useful insights concerning Canadian international competitiveness. Our discussion examines the Canadian economy as both a producer and a user of high-tech. This examination remains focused on information technology, but we believe that many of our analyses and comments are generally valid. Our study of information technology helps to explain why corporations decide to invest in different types of economic activities in different countries. And it shows how such investment decisions are related to international trade.

In examining the information industry, we need to modify the traditional dichotomy of capital *vs.* labour. Traditionally, trade analysts labelled some products as capital intensive and others as labour intensive. A nation's comparative advantage would be determined by the relationship between its stock of capital and its stock of labour, and by the consequent relationship between its cost of capital and its average wage rate. In this and other high-tech industries, however, capital is embodied in labour through education and skills training to significantly varying degrees. It is necessary to distinguish between those goods and services where the labour is largely unskilled, and those goods and services where the labour is, in effect, capital intensive. It is **not** appropriate to think of comparative advantage of high-tech sectors as a whole—as in much popular commentary about trade and investment today. Rather, a nation's comparative advantage depends upon the particular type of labour used in a particular type of high-tech good or service. We can expect that while Canada may be a net exporter of some high-tech goods and services, it will also be a net importer of other high-tech goods and services.

We believe that education and research are essential elements of technological progress. This perspective on international comparative advantage emphasizes its transitory or temporary nature. The rapid pace of technological progress implies that job descriptions and occupational categories will be continually changing, as will the mix of high-tech goods and services that a nation imports and exports. It suggests that new "market niches" will continually open up for firms that develop specialized advantages.

Parts B and C examine alternative government policies that may foster the creation and diffusion of new technology. Throughout the world, the creation and diffusion of new technology is regarded as the foundation for future economic growth and prosperity. Less developed nations are quickly adopting technologies that were created in the advanced economies of Western Europe and North America. This technology transfer has altered traditional patterns of comparative advantage and international trade. Meanwhile, the advanced economies have become increasingly concerned about their ability to innovate. This race for more efficient technology has become a major determinant of international competitiveness. As participants in this race, individuals and corporations now look to their governments for public policies to help them compete. For many societies, the ability of government to engineer a comparative advantage is of paramount concern.

Fear exists that Canada is losing this international race for new technology. Not surprisingly, this perception has led to criticism of government policies. Part B examines the traditional policies of tariffs, subsidies, government procurement, regulation, and the protection of intellectual property. The thrust of our analysis is how these traditional industrial policies have affected the operations of Canadian high-tech, particularly the information technology sector, and how these policies have become the focus of new international negotiations. When a government provides support for industrial expansion through such policies, then other nations may believe that their businesses are being subjected to unfair competition. Preferential treatment for domestic firms means that foreign firms encounter barriers to trade. It also means that they encounter a price structure that is replete with artificial price distortions caused by these protectionist policies. Previous General Agreement on Tariffs in Trade (GATT) negotiations have already led to a number of agreements that govern and constrain their use. Discussions between Canada and the United States concerning a free trade agreement have dealt with these policies, and they will be the subject of the forthcoming round of GATT negotiations.

The analyses and insights of Part A bear directly on the discussions of Part B. Within the new information technology sector

an overlap of form and function between computers, telecommunications, robotics, and microelectronics is causing the disappearance of product distinctions. International trade often involves the sale of several or all of these elements as part of a package. The transactions also include services such as consulting, software, and maintenance of physical goods. A national barrier to one element of the sales package may block the sale of the entire package. For example, a national barrier to consulting, such as restrictions on temporary immigration for work purposes, can pose a serious obstacle to trade in goods.

The relationship between the information technology firm and its customer is a relationship over time. Customers require continuing and immediate service, and this may require an ongoing commercial presence and the "right of establishment." From the perspective of Canadian firms, the investment restrictions of other nations could be extremely important, and Canadian negotiators must give them serious consideration. Agreements for effective freer trade may depend on agreements for freer international investment.

Another implication concerns government procurement codes. New international agreements might be enforceable with goods, guaranteeing equal access in the bidding process to both foreign and domestic firms. However, with information technology sales that include services and physical goods, such codes can easily be violated. When the customer receives competing bids for a package that includes hardware, software, telecommunications services, and consulting, the customer generally finds that no two bids are identical in what they offer, so that domestic preference can be easily justified. Trade negotiations dealing with government procurement codes should be based on an understanding of this difficulty.

A government's domestic regulations can also affect a foreign firm's ability to export to that market. Conforming with domestic regulations may be easier if the foreign firm has a domestic subsidiary and domestic employees. Again, this emphasizes the importance of the right of establishment. Conversely, opening up a market to foreign firms may automatically mean deregulation, both for foreign firms and domestic firms. These regulatory issues will be significant for many industries. Within the information technology industry, regulations concerning telecommunications are particularly important. For Canada, these regulations may become a subject of international negotiation. Furthermore, Canadian exports may depend on changes in other nations' regulations, without which our exports might be blocked.

These government policies will continue to affect Canada's high-tech sector. New international agreements that constrain a particular type of government policy may result in the expansion of other policies. The wide range of governing instruments discussed in Part B

provide an indication of the scope for such shifts in emphasis. Part C considers education and research as the most desirable and most likely focus for a new high-tech strategy. These elements are seen as having a fundamental role in both the process of technology diffusion and the process of adjustment to technological change. Program content and funding mechanisms for education and research take on a new importance in this context. Education is seen as including on-the-job training and retraining, while research is seen as including new processes to link university research with commercial applications. Governments are increasingly turning to education and research policies as a way of engineering a comparative advantage.

The use of public funds to assist corporate research poses a number of problems. For any particular project, the linkages are unclear between research, commercial applicability, and public benefits. To what degree will a particular research project result in new job creation, increased taxes, or productivity growth? In view of this, how much public funding should be allocated to each potential research project? What criteria should be used for accepting and rejecting corporate applications? With the new emphasis on joint research between corporations and universities, how will ownership of patents and copyrights be divided? After a research project has successfully reached the stage of commercial applicability, it is not clear what portion of the resulting investment and public benefits will remain in Canada. In the extreme, for example, publicly funded Canadian research and development could result in investments abroad whereby Canadians might lose the public benefits.

Since these problems have not been resolved—either in the academic literature or within government—they permeate the discussion and create an atmosphere of uncertainty for many policy recommendations. In view of their importance, these problems deserve to be the focus of research. Since they revolve around the responses of the business sector to a range of alternative policies, this research must focus on the process of business decision making within the context of the small, open Canadian economy that faces significant foreign ownership, an increasingly integrated world economy, and globalized competition.

This suggests some important implications for education and research policy. First, it is likely that the resolution of these problems will involve different answers for different types of businesses. Second, these answers may vary over time as elements of the business environment change, for instance, in response to technological developments. Therefore, wisdom in a Canadian approach may entail different research policies for different types of businesses at different times. In particular, the optimal use of public funds may carry conditions that relate to specific public benefits.

Yet many observers would question the ability of government to fine-tune or target research policies in this manner. Some may question whether legislation can be devised that can be appropriately detailed and at the same time be adequately flexible. It has been argued that civil servants do not have the expertise or the information necessary to make these allocation decisions efficiently. Furthermore, some of the research policies involve the subsidy issue discussed in Part B. Foreign corporations may see the public funding of certain research projects as a cause of price distortion and unfair competition. Future international trade negotiations may focus on these research policies and seek to constrain them.

Such concerns can lead to a preference for channelling public funds toward education as a means of facilitating the process of technological change. It is true that some individual beneficiaries may emigrate, thereby depriving Canada of the public benefits from their education. It is also true that the relationships between education and employment lack precision. Nevertheless, the uncertainties with education policy seem less severe than those with research. Consequently, a strong argument can be made that education policy is the best type of high-tech policy for Canada. These concerns can also lead to preferences for channelling public funds for research through educational institutions, rather than government laboratories. For example, matching grant programs can use public funds to match corporate contributions for university research, thereby encouraging research in those areas where commercial applicability is most likely to occur. This approach ensures that public funding of research will at least contribute to the education of Canadians, even if some of the benefits spill over into other countries.

The analysis and insights of the information technology study in Part A also bear directly upon the discussions of Part C. The role of labour qualifications as a determinant of corporate location decisions is particularly important. The high-tech sector includes a wide variety of occupations, requiring different levels of education and skills and paying different levels of wages. A society wanting to attract the high-tech activities that offer high wages must develop the corresponding levels of education and skills.

The information technology sector is undergoing constant change. To retain the best jobs and highest wages, a society must continuously re-educate and retrain its members. High-tech corporations continually find their sales mix changing, with new products and services combining to create new solutions. This trend has brought about a change of emphasis in production activities from economies of scale, based upon the cost savings resulting from specialization and large volume production, to economies of scope, based upon efficient ways of producing a variety of different goods and

services simultaneously. Retaining a competitive lead requires quick responses to the constantly developing needs of the market and changes in production processes. Indications are that this will result in greater labour requirements that emphasize skill level and adaptability as the key characteristics. From this perspective, education and research can be seen as essential mechanisms for creative adjustment in an ever-changing world economy.



PART A

**HIGH TECHNOLOGY: TRADE, INVESTMENT
AND COMPETITIVENESS**

Chapter II

Canadian Competitiveness

Introduction

It is becoming increasingly evident, as a result of a number of significant global trends, that large segments of Canada's manufacturing sector are not internationally competitive and, more important, that this situation must be remedied to avoid serious economic repercussions in the not too distant future. Canadian literature has, for some time now, pointed to low productivity and high costs of production in Canada as the source of these problems. More recently, the Royal Commission on the Economic Union and Development Prospects for Canada devoted a great deal of attention to this issue and emphasized the need for greater rationalization and specialization in Canadian manufacturing fostered by freer international trade as a way of overcoming this handicap. Although the commission also looked at technological changes in Canadian industry, the extent of the role of technology in improving Canada's overall economic performance and more particularly as a means of increasing the competitiveness of secondary industry, was not assessed.

In this chapter we describe the current trends in the world economy and the developments expected to transpire from the resulting increase in global competition. We then review briefly the latest evidence concerning structural change and adjustments in the Canadian economy in an attempt to gauge Canada's response to this

current of change apparently propelled by trade liberalization and technological developments.

Global Competition: The Changing World Economy

Some fundamental changes in the patterns of international trade, particularly since the early 1970s, have had and will continue to have tremendous implications for Canada's manufacturing sector. They have been the focus of several studies and are summarized in the 1986 study by Daly and MacCharles as:

- the increase in the frequency and size of exchange rate changes reflecting increased decentralization of trade and economic power in the world economy;
- the declining share of world trade held by the United States, reflecting a more rapid growth in exports, capital flows and domestic economic activity in Japan and Europe but also in certain developing countries;
- the increase in the share of total trade taken up by manufactured products along with a decline in the share held by natural resource products other than petroleum. This trend has been accompanied by an increase in the two-way flow of similar items between industrial nations. Despite the increase in manufacturing trade, manufacturing employment has remained relatively static in the industrial countries.

According to Daly and MacCharles (1986),

... Intra-industry trade reflects the reallocation of resources on a world-wide basis, as producers attempt to improve their efficiency and reduce unit costs in order to be more competitive (Daly and MacCharles 1986, p. 125).

These fundamental changes reflect a dramatic increase in global competition. Because of the complexity of this phenomenon it is difficult to distinguish between the elements which are the cause of this trend from those which are occurring as a result of it. The scheduled decline in import tariffs as a result of the Tokyo round of trade negotiations under the General Agreement on Tariffs and Trade is undoubtedly an important factor in the trend toward increased global competition. However, for other elements such as the adjustment of corporate investment strategies in favour of more

world-scale factories and the erosion of technological leadership in North America, the cause-and-effect distinction is not so clear.

As a result of these international trends a significant convergence in the economic prospects for most industrialized economies is becoming evident. According to Chandler and Trebilcock (1986) the following developments are expected to transpire:

- increased competition among the most industrialized nations for shares of basic industrial activities;
- increased competition from the newly industrializing countries (NICs) in many of the same industries where rapid technological diffusion and lower labour costs render established industrialized economies vulnerable;
- a technological race in productive processes to render basic industries internationally competitive, essentially by substituting capital for labour;
- a technological race among industrialized economies to produce new products that are intensive in physical and financial capital and specialized human capital, rather than unskilled labour.

Adjustments in the Canadian Economy

Although some Canadian economic indicators are already reflecting the impact of increased global competition, the overall assessment of the evolution and adaptability of Canada's industrial structure since 1960 is that Canada has not achieved a good productivity performance (McFetridge 1986). One of the objectives of the research conducted for the Royal Commission on the Economic Union and Development Prospects for Canada was to examine the degree to which Canada's industrial sector as a whole, and some of its various components in particular, have been able to respond to changes in technology and in the extent of international competition. The research program was an attempt to respond to

... the apparently widespread public perception that the Canadian industrial system is threatened in an unprecedented manner by: (a) major changes in technology such as those relating to the microchip; and (b) the emergence of new international competitors, largely in the Far East, coupled with declining natural and artificial barriers to trade. (McFetridge 1986, p.1)

These studies resulted in a number of important observations which, in some cases, offer somewhat mixed signals. The following is a summary of the major elements presented in McFetridge's overview and other recent evidence.

- The broad sectoral evidence is that the composition of Canadian output involves less manufacturing and more mining and services than most industrial economies (see Table 2.1). In both 1960 and 1981 Canada ranked near the top in terms of proportion of gross domestic product (GDP) accounted for by the service sector and near the bottom in terms of percentage of GDP accounted for by the manufacturing sector. Over the 1956-1981 period, the secular trend in Canada has been away from primary production toward services, particularly air transport, communications and miscellaneous services to people and businesses, with manufacturing maintaining a relatively stable percentage.
- The results of an international comparison of cumulative change indexes indicate that Japan has experienced the most structural change out of six countries examined, while Canada has experienced the least.
- There has been an increase over the last 20 years in Canadian exposure to and participation in international trade. The decrease in trade protection has brought an increase in import penetration and export orientation in virtually all manufacturing industries and an increase in intra-industry trade in most. The latter trend suggests an adjustment process by which manufacturers specialize in a few product lines that are sold domestically as well as abroad while remaining product lines are imported. Canadian manufacturing trade balances, as a fraction of total trade for the 1966-1983 period (see Table 2.2), suggest a poor and deteriorating competitive position for leather, knitting mills and clothing industries, and a large improvement for furniture and fixtures, rubber and plastics, petroleum and coal products, fabricated metals and printing and publishing. Nevertheless, throughout this period the highest trade surpluses consistently remained in the natural resource industries, i.e., paper and allied products, wood, primary metals, and petroleum and coal products.
- Measures of "revealed comparative advantage" (RCA)—expressed as the ratio of the national share of world exports for one industry to the national share of world exports for all

industries – produced by D'Cruz and Fleck (1985) have been used to study the evolution of the pattern of Canada's trade. The authors find that Canada is on average specialized in neither particularly high-growth nor low-growth industries but that over the 1967-1982 period the country has increased the degree to which it specialized in nine of the 10 slowest growth industries. The authors also calculate Canadian shares of the world market (Canadian exports expressed as a proportion of the combined exports of the largest three non-Canadian exporters in each industry) and found that between 1971-1976 and 1976-81, Canada lost market share in aggregate as well as in seven of nine classes of industries classified according to technological intensity and growth rate in world exports. Improvements in Canadian market share were experienced only in the medium technology, high-growth sectors and the low-technology, low-growth sectors.

- Much of the evidence on manufacturing, employment, output, trade balance and market share fails to support the contention that Canada has deindustrialized since 1960. "Indeed, the Canadian manufacturing sector can be regarded as having had some modest success when compared with its European counterparts" (McFetridge 1986, p. 21).
- The proportion of Canadian manufacturing assets that are foreign-controlled increased rapidly during the 1948-1963 period, remained constant during the 1960s, peaked in 1971-1972, and has been in decline since that time.
- Over the 1970-1980 period, Canada experienced counteracting trends in terms of industry producer concentration with highly concentrated industries becoming less concentrated and unconcentrated industries becoming more concentrated, although in aggregate, concentration has risen since 1975. This is seen as "a natural consequence of having efficiently scaled producers operating in the small Canadian market" (McFetridge 1986, p. 34).
- Seller concentration ratios provide another industry concentration measure which is particularly informative in the case of the Canadian economy. (This is a trade adjustment measure which takes account of the fact that there are sellers in the domestic market who are not producers and *vice versa*). Because imports and exports are relatively large in comparison to domestic production, seller concentration ratios in Canada are

generally lower than producer concentration ratios. In fact, Baldwin, Gorecki and McVey (1984) have found that when using the seller concentration measure, one half of the difference between the Canadian and the (still lower) U.S. average industrial concentration ratio disappears. Between 1970 and 1979, the average seller concentration ratio for Canadian manufacturing fell by 10 per cent as a result of the trend of increasing trade.

- The largest Canadian manufacturing plants are considerably smaller than their U.S. counterparts. Although this gap narrowed slightly during the 1970s, the average ratio of Canadian to U.S. plant size was only 0.818 in 1979 (Baldwin and Gorecki 1985). Product diversity declined between 1974 and 1979 and along with an increase in average plant size resulted in an average increase of 55 per cent in length of production run. According to the authors, the results imply that the tariff reductions which occurred in the 1970s had a positive impact, increasing the relative scale of plants in high-tariff, high-concentration industries and increasing run lengths, proportional to scale in all industries.
- Canada's recent productivity growth record over the 1960-1982 period ranks among the poorest of the countries in the Organization for Economic Cooperation and Development (OECD) surveyed. The productivity slowdown has been experienced in all sectors although between 1967-1973 and 1974-1980, the decline in the rate of productivity growth has been greater in some sectors, namely, mining, forestry, transportation, and communications.
- Average Canadian productivity was 73 per cent of U.S. productivity in 1979, about the same as it was in 1970 (Baldwin and Gorecki 1985). Research suggests that, depending on the measure used, between one-third and two-thirds of measured productivity differences are due to differences in scale. The balance is due to technical inefficiency, "a residual category which reflects differences possibly due to managerial efficiency or organizational design in output per worker" (McFetridge 1986, p. 51). However, Baldwin and Gorecki find that technical inefficiency depends on the degree of import penetration (indicating competitive pressure) but apparently not on other industry characteristics.

Table 2.1
International Comparisons of Share Distribution of Real GDP and Employment, Six Sectors,
Selected OECD Countries and Canada, Selected Years 1956-1981

	Primary		Mines		Manufacturing		Construction		Utilities		Services	
	GDP	Employ- ment	GDP	Employ- ment	GDP	Employ- ment	GDP	Employ- ment	GDP	Employ- ment	GDP	Employ- ment
(percent)												
Canada												
1956	16.4			2.1	25.7	7.4				8.9		39.5
1960	5.8		3.7	1.6	21.1	7.6	7.0		10.2	8.6	51.6	44.8
1970	4.3	7.7	4.0	1.6	22.8	6.7	6.0		11.7	8.8	50.6	53.3
1981	3.4	5.5	2.7	1.8	21.7	6.2	5.9		13.8	8.3	52.2	59.1
United States												
1956	11.2			1.4	29.2	5.1				7.2		45.9
1960	4.6	9.1	3.0	1.2	23.2	6.9	4.8		7.4	6.7	54.9	50.0
1970	3.4	4.7	2.9	0.8	24.0	5.7	4.8		8.4	6.1	56.7	57.7
1981	3.0	3.7	2.5	1.1	23.8	4.1	4.4		9.0	5.5	57.6	64.0
United Kingdom												
1956	4.6			3.7	37.1	6.7				9.1		38.8
1960	2.9	4.3	3.2	3.2	28.5	8.3	6.6		7.4	8.7	49.8	40.1
1970	2.8	3.2	2.1	1.7	30.1	8.6	6.8		8.0	8.3	48.4	45.3
1981	3.2	2.6	5.1	1.4	24.2	5.9	6.5		8.8	8.0	52.8	55.3
West Germany												
1956	16.9			3.1	36.5	7.6				8.7		27.2
1960	4.7	14.0	3.1	3.1	34.4	8.4	8.5		7.8	6.5	41.6	31.2
1970	3.3	8.6	1.8	1.2	37.9	7.3	7.9		8.3	6.4	41.4	36.4
1981	2.8	5.5	1.0	1.4	34.8	6.0	7.5		10.0	7.0	45.4	45.0
Japan												
1956	38.5			1.0	19.2	4.4				4.7		32.1
1964	9.9	26.8	0.8	1.1	23.9	8.4	6.2		7.3	6.5	49.6	35.6
1970	6.1	17.4	0.7	0.4	29.8	9.3	7.7		8.3	6.9	45.9	40.4
1981	3.4	10.0	0.5	0.2	35.9	7.4	9.8		7.3	6.7	45.5	48.4
Sample average												
1956	17.5			2.3	29.5	6.2				7.8		36.8
1964	5.4	12.2	2.3	1.4	27.4	8.3	7.0		8.0	7.4	48.6	42.1
1970	4.2	8.3	2.1	1.0	29.1	7.8	7.1		8.7	7.3	48.1	46.8
1981	3.4	5.4	2.1	1.1	27.8	6.2	6.9		9.9	7.2	50.7	54.8

Source: Charette, Michael F. et al. (1986). "The Evolution of the Canadian Industrial Structure: An International Perspective." in Donald G. McPetridge, research coordinator *Canadian Industry in Transition*. Toronto: University of Toronto Press, p. 75.

Table 2.2
Trade Balances in Manufacturing
[(Exports - Imports) / (Exports + Imports)] x 100

Industry	1966	1975	1980	1982	1983	Average 1966-82	Secular Trend
			(Per cent)				
Food and beverages	20.3	1.0	11.9	20.0	15.4	11.6	-
Rubber and plastics	-59.8	-63.7	-38.0	-11.0	-16.9	-42.4	+
Leather	-57.0	-74.9	-68.7	-68.8	-72.9	-69.4	-
Textiles	-73.8	-74.9	-59.4	-58.1	-64.8	-67.8	-
Knitting mills	-74.4	-93.6	-92.9	-92.9	-94.5	-90.8	-
Clothing	-41.5	-41.0	-35.3	-45.5	-55.0	-39.5	-
Wood	76.1	55.4	79.8	84.2	80.9	76.3	-
Furniture and Fixtures	-43.1	-45.5	-9.3	11.1	11.0	-21.7	-
Paper and allied products	89.0	82.0	86.6	93.4	81.0	85.1	+
Printing and publishing	-82.6	-73.7	-64.4	-64.8	-54.6	-70.2	-
Primary metals	40.9	35.3	35.4	42.3	35.0	37.6	-
Fabricated metals	-65.5	-52.4	-38.7	-34.7	-31.9	-45.5	+
Machinery	-56.9	-49.4	-47.7	-41.7	-41.8	-47.7	+
Transportation	-17.1	-11.7	-8.4	7.6	3.8	-4.7	-
Equipment and electrical products	-47.0	-47.5	-39.7	-33.8	-37.2	-42.9	-
Non-metallic minerals	-49.1	-45.5	-32.9	-24.9	-26.3	-33.6	+
Petroleum and coal products	-84.9	18.2	42.0	39.6	34.8	22.6	+
Chemicals	-27.7	-36.6	-7.6	-7.1	-14.4	-18.5	-
Miscellaneous manufacturing	-49.6	-67.2	-57.7	-54.8	-54.5	-60.6	-

Source: McFetridge D.G. (1986) "The Economics of Industrial Structure: An Overview," in D.G. McFetridge, research coordinator, *Canadian Industry in Transition*. Toronto: University of Toronto Press, p. 10.

In McFetridge's view, this description of the evolution and change in Canadian industry is not sufficient to draw performance implications. However, there are a number of elements which should be emphasized. There is, for instance, the fact that in spite of some improvements in the manufacturing sector in terms of output, employment, and trade balances, Canada's comparative cost advantage remains in natural resources, partially processed primary materials, and components that make intensive use of resources and energy in their production as opposed to manufactured end products.

This is reflected in the net position of the major trade categories. . . . Natural resources are all more abundant relative to employment in Canada than in any other industrialized country in the world. In addition, output per person in some of the extractive industries is substantially higher in Canada than in the United States. . . . These factors help to explain why over 30 per cent of Canada's exports are accounted for by fewer than 10 primary products, including wheat, wood, pulp, newsprint, lumber, copper, iron ore and copper and iron concentrates. Manufactured goods [on the other hand] represent a low share of total exports and high share of imports (Daly and MacCharles 1986, p. 127-128)

In his overview of the commission's research on Canada's industrial structure, McFetridge (1986) argues that even though the principle of revealed comparative advantage, as related to national factor endowments, is out of fashion at present, it still has merit. On the basis of this principle, the author sees no justification why Canada should reallocate its resources away from the primary sector. McFetridge also suggests that being one of the many entrants into a high-growth market may not be a better position to be in than being one of the fewer participants in a low-growth market, given that in theory, entry rates should equalize the rates of return. However, other commentators, such as Daly and MacCharles (1986) and Bishop and Crookell (1986), suggest that there are several reasons why Canada's secondary industry not only has to become more competitive internationally, but also why it would be unwise for Canada to continue to rely to a great extent on the contribution of its traditional areas of comparative advantage. This concern is related to the longer term implications for Canada's employment and trade.

Natural resources and partially processed materials, which are a major part of Canadian exports are being replaced with alternative materials or are being used with greater

efficiency as a result of increased R&D efforts and continuing technical change. Further new sources of supply for resources have been developed in other parts of the world (p. 127) On both a national and a broad commodity basis, it is clear that the structure of Canadian exports is heavily concentrated on products that account for a falling share of world trade. The fastest-growing markets are in countries and products where Canadian market shares are low and stagnant because of comparative cost disadvantages. This combination has unfavourable implications for the national trade balance and longer-term employment prospects. Without conscious efforts on the part of the private sector to improve productivity and competitiveness, Canada will remain a hostage of its current comparative advantage in slow growing products (Daly and MacCharles 1986, p. 129).

A Pearson and Salembier (1983) study on trade, employment and adjustment examined the concepts of comparative advantage and international competitiveness. The authors found that the concepts are "somewhat elusive and highly inter-related," and thus easily confused. They argue that it is important to make the distinction between comparative advantage and international competitiveness because policy decisions may depend on it. Pearson and Salembier propose the following working definition:

Comparative advantage refers to the ability of one economy to produce a given good more efficiently – that is, at a lower opportunity cost – than a second economy. This ability is derived from the relative economic endowment of resources, technology, and economic structures in the two countries. Comparative advantage, therefore, involves a double comparison of cost and price relations. It is the comparison of the structure of costs among various domestic products as compared to the structure of costs of these products in other countries. At a point in time, all countries have a comparative advantage in one set of products and a comparative disadvantage in another set of products. It follows that comparative advantage refers to specific products as opposed to all the products produced by an economy.

International competitive position, on the other hand, can refer to an individual industry or to an economy as a whole. It involves the single comparison of nominal costs and

prices between two producers (economies) of the same product (set of products) offered to a given market. Whereas a tariff on a particular product does not alter a country's natural comparative advantage, it does improve the competitive position of the protected industry in its own domestic market. This is done by putting foreign producers selling to that market at a competitive disadvantage. Similarly, an economy's overall competitive position will be affected by the nominal level of prices and wages, the exchange rate and other macro-economic factors relative to those in other countries (p. 7).

The concerns cited above relate more to the issue of Canada's competitive position in the world economy. Given the trend toward globalized competition and the fact that Canada may have become less competitive in its areas of comparative advantage, we can argue that it is disturbing that the rate of structural change in the Canadian economy appears not to have accelerated in the past few decades.

The evidence presented suggests that the Canadian economy may not only be relatively unresponsive to changes in the international marketplace, but that we may also be specializing further in low-technology, low-growth sectors. The following tables, taken from the latest OECD Science and Technology Indicators (1986), provide an overview of the competitive position of Canada's manufacturing industries in comparison with those of other OECD countries, in particular with respect to the relative importance and competitiveness of R&D-intensive industries. The OECD figures tend to confirm some of these observations. In these tables manufacturing industries are categorized according to R&D intensity with all information technology industries classified as high-intensity.

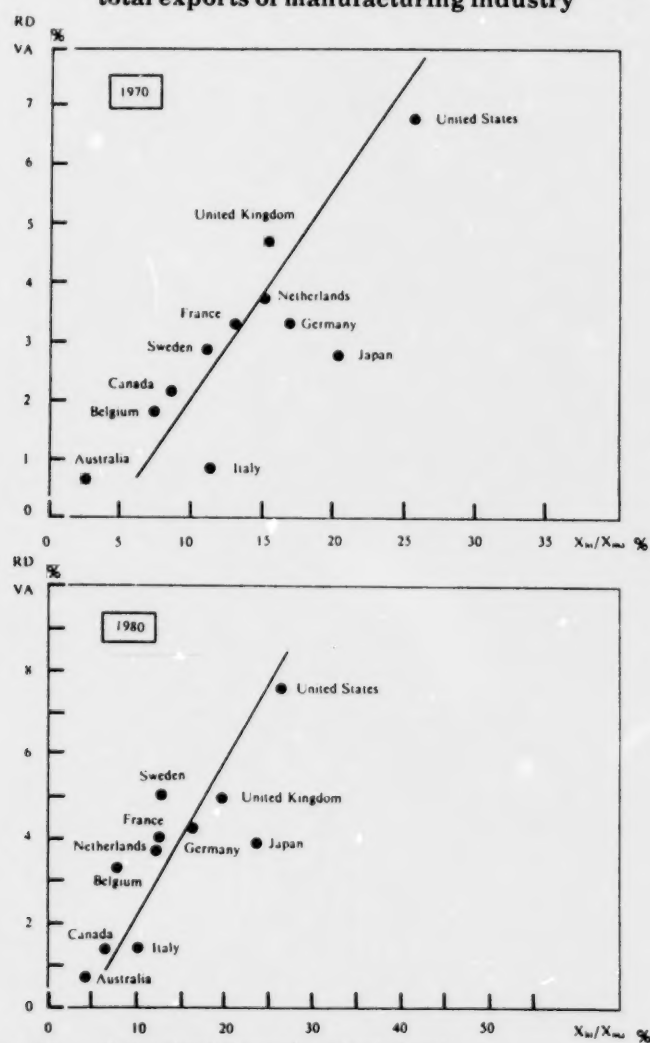
Table 2.3 reports shares of manufacturing industry output as a percentage of OECD output for 11 countries. The figures demonstrate Canada's relative importance as a producer in all levels of industry. Canada's largest shares of OECD output are, as expected, in wood and paper industries, and mainly other low-intensity industries with the exception of motor vehicles. The lowest shares of OECD output for Canada appear in high-intensity industries, although the shares in aerospace and electrical machinery are slightly higher than that of most medium-intensity industries. The Canadian share of output for the computer industry is the lowest of all countries, while that for electronic components is only slightly higher than Australia's and Belgium's. The relative weakness of Canada's high-intensity industries is well illustrated in Figure 2.1. It provides a comparison of the size of R&D expenditures as a percentage of value-added and the ratio of high technology industries' exports to total manufacturing

Table 2.3
Share of manufacturing industry in OECD output (11 countries)

	United States		Japan		Germany		France		United Kingdom		Italy		Canada		Australia		Sweden		Netherlands		Belgium	
	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980	1970	1980
High Intensity																						
Aerospace	80.9	60.6	0.9	1.0	2.5	5.8	4.7	14.3	5.4	10.2	1.3	1.6	2.0	2.5	0.4	0.9	1.0	1.5	0.4	1.6		
Computers	52.3	48.6	10.5	17.0	10.1	10.3	4.9	5.8	6.4	6.3	10.1	6.0	1.3	0.7	0.2	1.0	2.1	1.2	0.9	1.8	0.7	0.9
Electronics - components	48.4	33.3	21.7	28.8	7.4	9.0	4.3	8.1	8.4	7.5	2.9	4.6	1.8	1.4	0.6	0.6	1.0	1.8	2.2	3.3	0.8	1.2
Drugs and medicines	41.6	33.2	16.6	18.5	10.5	13.9	9.9	13.2	5.9	7.7	6.3	2.1	1.5	0.9	1.1	0.7	1.0	1.5	1.8	1.1	1.4	
Instruments	51.9	44.1	18.9	26.0	12.3	13.0	4.1	4.3	6.8	7.2	2.3	1.4	2.0	1.5	0.3	0.5	0.6	0.7	0.2	0.8	0.08	0.03
Electrical machinery	42.7	37.2	17.8	23.0	11.3	12.4	6.6	9.2	7.7	8.1	6.0	7.4	2.8	2.5	1.1	1.0	1.3	1.5	1.5	2.3	0.8	0.9
Medium Intensity																						
Motor vehicles	49.8	40.4	13.9	19.6	10.8	13.5	6.0	8.2	6.9	4.6	3.6	4.3	4.5	4.2	1.3	1.0	1.2	1.7	0.2	0.5	1.3	1.6
Chemicals	45.8	43.6	14.1	14.3	12.5	13.0	6.0	7.8	7.8	7.3	5.3	4.3	2.5	2.3	1.1	1.2	0.9	0.8	2.0	3.2	1.5	1.9
Other manufacturing industries	54.3	40.0	16.0	25.5	6.1	8.3	6.3	9.7	5.1	5.9	4.5	4.5	3.3	2.5	0.9	1.0	0.6	0.7	0.3	0.7	0.1	0.2
Non-electric machinery	46.1	38.1	15.7	17.5	12.3	14.3	6.8	9.8	7.2	7.9	5.5	5.1	1.7	1.9	0.8	0.7	1.7	1.9	0.6	1.0	1.0	1.2
Rubber, plastics	45.3	39.3	17.1	23.8	7.3	7.2	6.9	10.0	9.2	6.9	6.0	5.0	2.6	2.3	1.5	1.4	1.1	0.9	1.1	1.3	1.2	1.4
Non-ferrous metals	47.7	46.4	15.2	12.3	11.2	9.9	7.2	9.9	7.2	6.9	3.0	3.0	2.1	1.7	1.9	4.6	1.7	1.6	0.9	1.5	1.4	1.8
Low Intensity																						
Stone, clay, glass	38.7	31.0	16.5	22.2	11.5	11.0	6.2	10.7	7.6	7.5	9.2	7.2	2.9	2.7	1.6	1.8	1.6	1.3	1.4	1.8	2.3	2.4
Food, drink	46.7	40.0	10.6	16.0	7.2	8.4	9.5	10.6	9.2	8.7	4.8	4.6	4.2	3.4	1.9	1.9	1.5	1.3	2.7	3.3	1.2	1.4
Shipbuilding	34.1	35.6	28.6	22.1	8.1	6.4	5.9	7.2	7.0	6.3	3.5	3.8	2.2	2.1	1.1	1.4	4.9	3.8	3.0	4.3	1.1	2.6
Petroleum refineries	49.1	51.2	10.1	15.1	8.5	3.7	12.3	9.9	7.7	7.4	3.6	3.5	3.5	3.0	0.4	0.2	0.6	1.4	2.2	3.1	1.3	1.1
Ferrous metals	34.5	34.5	20.6	23.2	12.3	11.5	7.9	7.8	6.9	7.5	6.8	5.7	2.7	2.9	1.5	1.5	1.7	1.5	1.6	0.8	3.1	2.7
Fabricated metal products	45.4	42.6	17.7	20.7	11.2	13.0	4.1	5.6	8.8	5.6	3.9	3.2	3.3	3.3	1.3	1.6	1.7	1.7	1.2	1.5	0.9	0.9
Paper, printing	53.6	46.3	11.6	15.8	8.0	7.1	5.3	7.2	7.4	7.0	3.8	2.9	5.5	5.3	1.1	1.3	2.8	3.2	1.6	2.4	0.8	0.9
Wood, cork, furniture	40.7	34.2	20.1	21.8	8.5	12.3	6.2	7.6	6.0	5.6	4.9	3.3	5.8	6.2	1.6	1.8	3.5	3.8	1.0	1.4	1.3	1.6
Textiles, footwear, leather	44.0	37.2	12.5	17.6	11.0	11.6	8.2	10.1	7.8	7.1	8.1	8.3	3.2	3.3	1.1	1.1	0.8	0.6	1.4	1.1	1.4	1.5

Source: OECD, 1986. *OECD Science and Technology Indicators, R&D, Innovation and Competitiveness*. No. 2. Paris: OECD, p. 117.

Figure 2.1
R&D intensities and weights of high R&D intensity industries
total exports of manufacturing industry



Where: VA: Value added of manufacturing industries
RD: Total R&D expenditure of manufacturing industries
Xht: Exports by high-intensity industries
Xma: Exports by manufacturing industries

Source: OECD (1986) *OECD Science and Technology Indicators*. No. 2. Paris: OECD, p. 100.

exports. Canada's position appears to have deteriorated further during the 1970-1980 period.

Tables 2.4 and 2.5 report additional information about the Canadian economy and the relative importance of R&D-intensive industries. Measures of apparent comparative advantage indicate whether a country exports proportionally more of one good than other goods, or whether a country exports proportionally more of a particular good than other countries. If the coefficient obtained exceeds 100 it indicates a comparative advantage whereas a coefficient of less than 100 indicates a disadvantage. The specialization by niche measure, on the other hand, indicates a country's independence given the size of its internal demand. The degree of specialization is indicated by the extent to which it produces more than it consumes. Hence, the higher the value of this indicator, the greater the country's specialization. Values close to 100 suggest that specialization is balanced.

Table 2.4 demonstrates that only five countries had a comparative advantage in high R&D intensity industries. However, as the OECD report emphasized, Switzerland's position has been in steady decline since 1974 and Ireland's record reflects simply the growth of exports of electronic equipment and computers by American firms which have been set up there and which import the technology required for their electronic exports. The United States maintains the lead in "the field of dissemination of technology through the export of goods" (OECD 1986, p. 65), with Japan ranking second but closing in rapidly. These figures also suggest a deterioration of the position of the European Economic Community (EEC) in this respect. Canada displays a medium-to-low range position but it, too, is losing ground. The numbers indicate that Canada's strength is in the medium R&D intensity industries with a fair representation in the low-intensity industries.

The figures in Table 2.5 demonstrate that in only five countries do the high-intensity industries produce more than internal demand. Japan is the most specialized, followed by Germany and then the United States. These same five countries also lead in medium-intensity industries with Germany preceding Japan. Canada is showing growing specialization in low-intensity industries; close to balanced, but decreasing specialization in medium-intensity industries; and further weakening in high-intensity industries.

Canada's overall record in terms of competitiveness is perhaps best reflected by its productivity performance. As McFetridge indicates, almost all industrial countries experienced slower productivity growth in the 1970s than in the 1960s. However, the figures indicate that "Canada has suffered a proportionately greater

Table 2.4
Apparent comparative advantage of manufacturing industry
OECD average = 100

	High R&D			Medium R&D			Low R&D		
	1970	1980	1984	1970	1980	1984	1970	1980	1984
United States	158	156	156	109	106	98	63	64	64
Japan	123	141	147	78	105	101	114	75	68
EEC ¹	93	93	82	105	101	99	97	102	114
Germany	96	93	82	124	117	119	76	82	86
France	85	81	83	94	98	95	110	108	114
United Kingdom	104	121	118	117	108	98	81	80	89
Italy	77	62	56	99	91	90	111	128	141
Netherlands	97	76	62	62	71	74	139	143	156
Belgium-Luxembourg	44	47	37	94	98	101	127	125	137
Denmark	72	75	66	62	63	60	150	154	171
Ireland	71	113	159	21	56	54	192	146	120
Greece	14	17	13	60	35	31	176	211	244
Canada	55	48	43	124	108	127	91	112	100
Australia	17	26	19	66	71	78	160	166	169
New Zealand	4	9	9*	9	24	29*	233	231	234*
Austria	69	73	63	72	79	85	141	137	142
Finland	19	36	30	36	50	48	199	192	210
Iceland	0.6	3	0.5*	64	46	76*	176	208	183*
Norway	28	38	32	90	93	100	139	136	142
Portugal	46	59	49*	36	34	40*	188	196	199*
Spain	37	43	34*	62	86	83*	165	143	157*
Sweden	73	78	67	83	87	88	128	125	136
Switzerland	185	160	128	105	113	114	61	57	64
Turkey	11	9	10	46	35	28	192	218	249

* 1983

1. Excluding inter-EEC trade
Apparent comparative advantage = share of an industry in country's total exports of manufacturing, compared with the same indicator for all OECD countries which equals 100

Source: OECD (1986) *OECD Science and Technology Indicators*. No. 2. Paris: OECD, p. 71.

Table 2.5
Specialization by "niche" of manufacturing industries

	High intensity			Medium intensity			Low intensity		
	1970	1975	1980	1970	1975	1980	1970	1975	1980
United States	105	110	109	101	105	102	97	97	
Japan	109	114	126	104	112	118	106	106	102
Germany	118	121	115	127	145	137	98	102	95
France	100	104	102	101	109	104	101	102	100
United Kingdom	108	113	108	112	114	109	96	94	96
Italy	99	99	94	106	117	105	102	107	106
Canada	81	73	66	103	83	90	104	101	108
Australia	61	66	64	82	83	84	103	103	102
Netherlands	93	100	97	78	100	105	105	114	108
Sweden	89	97	95	97	100	107	104	102	103
Belgium	77	81	79	102	104	98	122	116	114
EEC	106	110	104	112	121	115	100	101	99

SN = 100 x output/domestic demand (domestic demand = output - exports + imports)

Source: OECD (1986) *Science and Technology Indicators*, No. 2. Paris: OECD, p. 71.

productivity slowdown than most OECD countries" (McFetridge 1986, p. 48), and the rate of growth has been even slower in recent years. Although all sectors have experienced a decline, the productivity slowdown has been greater in mining and forestry where Canada has a comparative advantage. In the case of the mining sector the decline is attributed to the substitution toward labour between 1974 and 1980 but there is more controversy concerning the causes of the general decline in the rate of productivity growth.

Helliwell et al. (1985), for example, attribute 70 per cent of the decline in productivity growth to underused capacity and rising energy prices, with 30 per cent unexplained. Grey and Foote (1983) attribute 13 per cent to a declining rate of increase in capital intensity, 50 per cent to energy prices, 11 per cent to slower growth in demand, and 24 per cent to change in the age and industrial composition of the labour force, leaving nothing unexplained. Sharpe (1982) cites evidence to the effect that the entire slowdown can be explained by the incorrect measurement of the flow of capital services in recent years (McFetridge 1986, p. 49).

However, these estimates are not accepted at face value by many observers (see Denny 1986, Daly and MacCharles 1986). For the most part, it is argued that the relatively short-term, cyclical factors cited above fail to account for the fact that productivity growth has been considerably lower in Canada than in Japan, France, and Italy for quite some time. These observers have preferred to look at adjustment behaviour, such as the rate of improvement in organizational design and the shifting of resources from the low-growth to the high-growth sectors for answers to these questions.

Conclusion

The major contribution of the research conducted for the Royal Commission on the Economic Union and Development Prospects for Canada on the evolution of the Canadian industrial structure is in pointing out the positive changes brought on by trade liberalization and the potential benefits to be gained from further moves in that direction. These include better trade balances, greater specialization, increased relative scale of plants and longer production runs. However, aside from pointing out the lack of dynamism in the rate of structural change, the relatively poor productivity growth performance and the more or less constant gap in Canadian factor productivity compared with the United States, the research does not really answer the question as to how Canada has responded to

changes in technology and in the extent of international competition. In fact, the D'Cruz and Fleck (1984, 1985) studies, which are reported by McFetridge (1986) as an outside source of reference, provide the most pertinent results. These results, which need to be interpreted with some caution, suggest that Canada's adjustment performance has been poor but, more important, that Canada is failing to reallocate resources from low-growth to high-growth sectors. Recent evidence reported by the OECD (1986) tends to confirm these observations.

The commission's research does not specifically assess the role of the technology factor in explaining Canada's overall economic performance and competitiveness within the global economy. A possible explanation might be that in the economic models used, technology is treated as a residual category or by means of proxies such as the level of education of employees or the proportion of employees who are scientists or engineers due to methodological problems and statistical difficulties. Given current indications that technology may be a strategic element at play in global competition, it remains important to evaluate its relevance to the Canadian economy.

Chapter III

Canada as Producer and User of New Technology

Introduction

The process of technological change has been characterized by historian Dudley Dillard (1967) as interdependent, cumulative and irreversible: interdependent in the sense that the application of a new technology in one activity stimulates application in other activities; cumulative in that one innovation leads to another with each succeeding development encompassing elements from previous ones; and irreversible in the sense that technological change dictates the development of production processes and organizational structures that are irreversible. On the basis of these characteristics, one can easily infer that this process plays a significant role in modifying the composition and structure of the economy. Today commentators ascribe a strategic role to technology, a role that relates directly to future economic success in a world characterized by increasing global competition. It is also common to hear concerns expressed over Canada's future in this context.

In this chapter we review the latest studies on innovation, technology and technological change to identify who are the producers and users of new technology and what are the patterns that emerge. We then examine Canada's record in this respect. In the last section we look at the issue of technological change and its impact on employment. The issues of job displacement, de-skilling, and the argument that technological change is causing an erosion of the middle-income occupations, and therefore, the middle-income class,

are often cited by those who view technological change as a process requiring intervention rather than support. It is important to put these concerns into perspective. Ultimately the question is one of adjustment and it is at that level that public policy can make a contribution.

The Importance of Technology

Technological change is a relatively complex phenomenon and as such, it is difficult to define. Perhaps the most useful conceptual framework through which to view the role of technological development is that commonly described as the Schumpeter trilogy. This framework treats the phenomenon of technological change as made up of three interrelated stages: (1) invention which involves the generation of ideas, (2) innovation consisting of the development of ideas into marketable products, and (3) diffusion whereby the new technology is spread throughout the economy.

R&D capital accumulation, invention and innovation decisions involve a number of significant economic issues. First, there is the lag between past investment expenditures and their outcome. This lag represents an adjustment process that can extend over several years. Also new production techniques usually lead firms to expand output and to alter the relative use of the various inputs in the production process. Product development can also affect the demand conditions facing firms.

As new technology is introduced, production costs will fall or product quality will be enhanced. If demand is sufficiently responsive to improved quality, or prices fall as costs fall, and demand is sufficiently responsive to price, output will increase. If this output increase is sufficiently great when costs fall, it can more than offset reduced input requirements per unit of output and thus, increase total input demand. If demand increases when product quality increases, this can also offset any changes in input per unit of output (OECD 1987, p. 14).

It is through the economic impact of technology that we can distinguish between process innovations (those that generate cost reductions) and product innovation (those that generate demand shifts). This distinction is felt by many observers to be of significant importance in the policy debate.

Two properties help to explain the level of interest in product and process development activities: spillovers and learning curves.

... spillovers originate from innovations, inventions, and the knowledge capital inputs of a firm. The externalities find their way throughout the economy by various means, such as by purchasing products, using patented inventions, entering into contractual agreements on innovations, and hiring factors of production. Spillovers, by their nature, are intimately related to the spread of knowledge throughout industries and economies. They provide a source of the linkages through which the diffusion of technological change occurs (Bernstein 1985, p. 5).

It is important to point out that the positive externalities can accrue at various levels—individuals, firms, and nations—and that as a result of these, the innovating firm may be unable to appropriate the full return from its investments. Therefore, the firm will probably only engage in such activities to a degree that is less than socially optimal. On the other hand, activities such as the production of technology intensive goods and services are thought to be characterized by a learning or experience curve and to hold the potential of long-term, above-normal profits. This potential makes such activities particularly attractive.

An experience curve is simply a relationship between the cost of production and accumulated production volume. The greater the accumulated volume, the lower the per unit cost. A firm which is the first to enter into a market and which builds up sufficient production volume (experience) can confront potential rivals with a production cost advantage that will deter them from entering. This is called pre-emption of the market. Successful pre-emption implies a monopoly, perhaps a world-wide monopoly of the market in question... The learning curve which has served to lower unit costs is a sunk or market-specific asset. It is this "sunkness" which serves as the barrier to the entry of new competition as the market develops (McFetridge 1985, p. 18).

Technology is often perceived as a potential solution to such problems as low productivity and competitiveness, inadequate output growth and income disparities. This attitude is based in part on the "generally established empirical result that R&D investment has a significant and positive influence on productivity growth and thereby also on the growth of output" (Bernstein 1985, p. 15). There has been a lot of interest in the literature in analyzing the relationship between

R&D, capital and total factor productivity (TFP). The results from some of these studies are reviewed by Bernstein (1985).

There have been several studies in the United States on the effects of R&D investment on output expansion and factor substitution possibilities. Indications are that such an influence does exist. For instance, in the 1980 study by Terleckyj of 20 U.S. manufacturing industries, it is estimated that 30 per cent of TFP growth is accounted for directly by the R&D investment undertaken in the industry under consideration whereas 78 per cent TFP growth resulted through indirect effects such as those which arise from intermediate and capital input purchases. Mansfield (1980) also observes a significant influence on TFP growth exercised through an industry's purchases of inputs. Scherer (1982), on the other hand, finds that while the direct and particularly the indirect effects of R&D capital exerted a significant effect on TFP growth for U.S. manufacturing industries during the 1945-1965 period, this relationship seems to have weakened during the 1970s.

The Nadiri and Schankerman (1981) study is particularly interesting in that TFP growth is decomposed into a factor price effect and a product demand effect (defined as the scale effect) and an R&D effect and an autonomous technical change effect (defined as the technological effect). The analysis focuses on total manufacturing, durables and non-durables over the 1958-1978 period. The authors find that the technology effect was dominant in the early period—with technical change accounting for 75 per cent of TFP growth for manufacturing and durables—while the scale effect was more important in the later years with product demand effects accounting for about 65 per cent of TFP growth for manufacturing and durables. The impact of R&D capital increased in the later period for all categories, but it accounted for the smallest proportion of TFP growth for manufacturing and non-durables.

Similar studies for Canada also point to a link between growth rates of TFP and R&D capital. This evidence, however, is generally weaker and not as prevalent as is the case for the United States. Bernstein reports two studies for Canada, that by Lithwick (1969) who reported no observable link between these two variables and that by Switzer (1984) who found that 60 per cent of TFP growth was explained by privately financed R&D capital.

Several studies have focused on the effects of R&D capital accumulation on labour productivity growth rates. For instance, Griliches' (1979) estimates for six U.S. industries indicate that on average 30 per cent of labour productivity growth results from R&D capital investment. Nadiri's (1980) estimates suggest this rate may be as much as 35 per cent for the whole of the private sector in the United States. In Canada, Longo (1984) reports that on average (over

all firms) the growth in R&D capital explains approximately 60 per cent of labour productivity growth. The conclusion drawn by Bernstein (1985) from his review of the literature is that R&D investments clearly have a positive effect on productivity growth (20 to 60 per cent for Canada), but this effect tends to vary over time and between industries. The significance of indirect effects through input acquisitions points to the importance of interlinkages and embodied technology.

Canada as a Producer of New Technology

OECD figures on R&D expenditure as a percentage of gross national product (GNP) indicate that although there has been a steady increase in Canadian R&D expenditures from 1975 to 1983, the 1983 rate (1.34) is only marginally larger than that for 1971 (1.32). Moreover, Canada's rate is the lowest of the eight countries reported. The highest rate is in the United States (2.70) followed by Japan at 2.61. The rate in the Netherlands is the second lowest, but at 2.03 remains considerably higher than Canada's. More recent data for the period 1984-1986 indicate that Canada's relative position in R&D spending has not changed. What has changed is the composition of national R&D expenditures, with direct government spending on R&D now accounting for a decreasing fraction and business spending on R&D an increasing fraction. This is seen as an improvement by many observers.

However, comparisons of national R&D expenditure data, as a percentage of GNP, are not satisfactory. As the Economic Council of Canada (1983) pointed out, there are many reasons why these indicators (gross expenditures on R&D/GNP ratios) may not be particularly informative in terms of determining the appropriate level of R&D expenditures for Canada. To begin with, such comparisons imply that the ratios of other countries are at the appropriate levels. They also imply that what is appropriate for other countries is also appropriate for Canada. However, the determinants of R&D expenditure vary widely from country to country. The most obvious example is that some countries—for example, the United States, France, the United Kingdom—devote considerable sums of money to space and defence research programs, whereas others—such as Japan—choose not to. Structural characteristics also affect individual country R&D intensities. Determinants such as market size, the relative importance of the manufacturing sector relative to natural resources, access to cheap sources of know-how, and the size of the national scientific infrastructure all play important roles and are all subject to national variations.

A model taking account of the inter-country variations in the levels of those variables considered to be major determinants of R&D expenditures has been constructed by the Economic Council of Canada (1983).

The results indicate that on a broad sectoral basis the actual level of R&D spending in Canada is far above expectations in the mining sector, about equal to expectations in the agriculture and tertiary sectors, and far below expectations in the manufacturing sector. Overall, the actual degree to which Canada "under-invests" in R&D is less than broad international GERD/GDP comparisons would suggest. The major source of Canada's below-average GERD/GDP ratio is low R&D spending levels in the manufacturing sectors (Economic Council of Canada 1983, p. 37).

According to the council, these preliminary results indicate that GERD/GDP ratio comparisons may be misleading. Ultimately, the decision to invest in R&D is a function of private rates of return for firms and social rates of return for governments. Empirical results indicate that the rate of return to R&D capital ranges on average from 20 to 60 per cent in Canada and 20 to 70 per cent in the United States. As Bernstein (1985) concludes, these (apparently private) rates of return are considerably higher than returns on physical capital. However, considering the measurement and estimation problems in this area, it would be premature to assume that there has been under-investing in R&D in the private sector. Bernstein also found evidence that the social rates of return to R&D capital may be considerably higher than the private rate of returns discussed above. This indicates the presence of spillovers, or positive externalities, which raise the question of the adequacy of government R&D support.

Patent statistics are considered an important indicator of technological change. The Ellis and Waite (1985) study looks specifically at the flow of technology available to Canada and the changes in the nature of that flow based on data from the publications of the World Intellectual Property Organization (WIPO), and from the Canadian Patent Office. It appears that a decline in the rate of invention has been experienced worldwide. The figures indicate that the rate of invention (as measured by rates of patenting), reached its highest level in 1972 at 136 per cent of its 1930 level, and fell to 116 per cent of the 1930 level by 1982. Rates of technology diffusion, which accounted for two-thirds of the total growth in patenting since the period between World War I and World War II, fell faster than the rates of invention in the 1970s. By contrast, Canadian rates of

patenting have been relatively stable, reaching 136 per cent in 1972 and coming close to this level again in 1981. As expected, however, these figures show that

As a source of new technology, Canada remains a small player, creating only 0.3 per cent of the world's patented inventions compared to Japan at 9.9 per cent, the United States at 8.0 per cent, Germany at 1.9 per cent and France at 1.8 per cent. Canada's relatively small economy is not sufficient to explain this, since Canadian domestic patenting rates appear comparatively low even when indexed to GNP. However, Canada has fared better than most in maintaining its world share of technology generation. Canada's share remained stable throughout the 1970s and early 1980s, while the shares of the other countries have been reduced by varying amounts (Japan is the exception here, with a steadily increasing share.) (Ellis and Waite 1985, p. 73).

As a recipient of new technology Canada fares quite well. It grants the third highest number of patents to foreigners after the United States and Britain. Although a substantial share of these patents originate from the United States, this share has been falling in recent years and Canada ranks fourth in the world as a recipient of non-U.S. patents. These data illustrate Canada's enviable position as a recipient of a large flow of detailed information about new technologies not available to other countries. Theoretically this puts Canada at an advantage as a potential user. The patents data analyzed by Ellis and Waite also indicate that Canada has responded relatively well to private market signals in terms of moving out of stagnant areas and into active areas of technology. Given the high turnover in the identity of active classes, this is an important element of performance. In general, these observations suggest that Canada depends to a considerable extent on other countries to obtain the technology it needs through purchases and licences from abroad. The United States continues to dominate technology in all areas. However, this dominance is lessening and Canada's increasing reliance on non-U.S. sources of supply to provide the technology it requires is seen as a desirable trend.

Technology Diffusion

Technology diffusion is the process by which technology spreads from its source to its users. Diffusion of technology can be studied from the perspective of the firm, the industry or the nation or a combination

thereof. Inter-industry diffusion from a national perspective is of particular interest in the context of differentiating between the generators and the users of technology and identifying the relative impact of each on productivity growth as well as providing information on the nature of the spillovers or externalities involved (see McFetridge and Corvari 1985).

As previously indicated, the United States remains the major source of new technologies. However, there is evidence that this share is falling and that Japan, Germany, France and, to a lesser extent Britain, are making strong gains in this area (see Mansfield 1985). Research on the patterns of technology flows indicates that innovations originate in relatively few countries. Furthermore, survey results show that relatively few industries provide most of the embodied new technology.

For example, four industries (machinery, electrical products, chemicals and other manufacturing) were the industry of manufacture in 80 per cent of the patents issued in 1978. The four largest users (machinery, transportation, equipment, electrical products and chemicals) accounted for 49 per cent of the use (McFetridge and Corvari 1985, p. 201).

According to Pavitt (1983), innovations originate in relatively few sectors but are applied on a wider basis. This emphasizes the importance of the diffusion process and the need to understand the inter-industry flows of technology. These flows can take the form of ideas and suggestions from competitors, suppliers and customers, or the technology can be embodied in goods and services purchased by one industry from another. For instance, the De Melto et al. (1980b) study reported that for 96 out of 283 innovations studied in Canada, the technology came from outside the innovating firm. In 55 per cent of these cases the source of technology was the parent firm while in 19 per cent of the cases it came from a supplier or customer and in 11 per cent of the cases from a consultant.

It is not surprising to find that the industries that produce the majority of innovations also provide the greatest fraction of their own technological requirements (electrical products, machinery, chemicals and other manufacturing). Industries such as construction, agriculture, forestry and fishing, leather, food and beverages and textiles are the most dependent on external sources for their technological requirements. For example, the Seguin-Dulude (1982) study indicates that of 392 patents for which agriculture was listed as the user in 1978, the suppliers listed were machinery for 50 per cent of patents, chemicals for 18 per cent, pharmaceuticals for 7 per cent and

food and beverage for 6 per cent. Regardless of the methodology, there is overall agreement in the literature that

industries which are the major sources of technology are also the major users of it. R&D intensive industries tend to buy R&D intensive inputs. The most important destinations of new technologies are not the non-technological using industries but the "high-tech" sources industries. All measures are in agreement on this matter (McFetridge and Corvari 1985, p. 207).

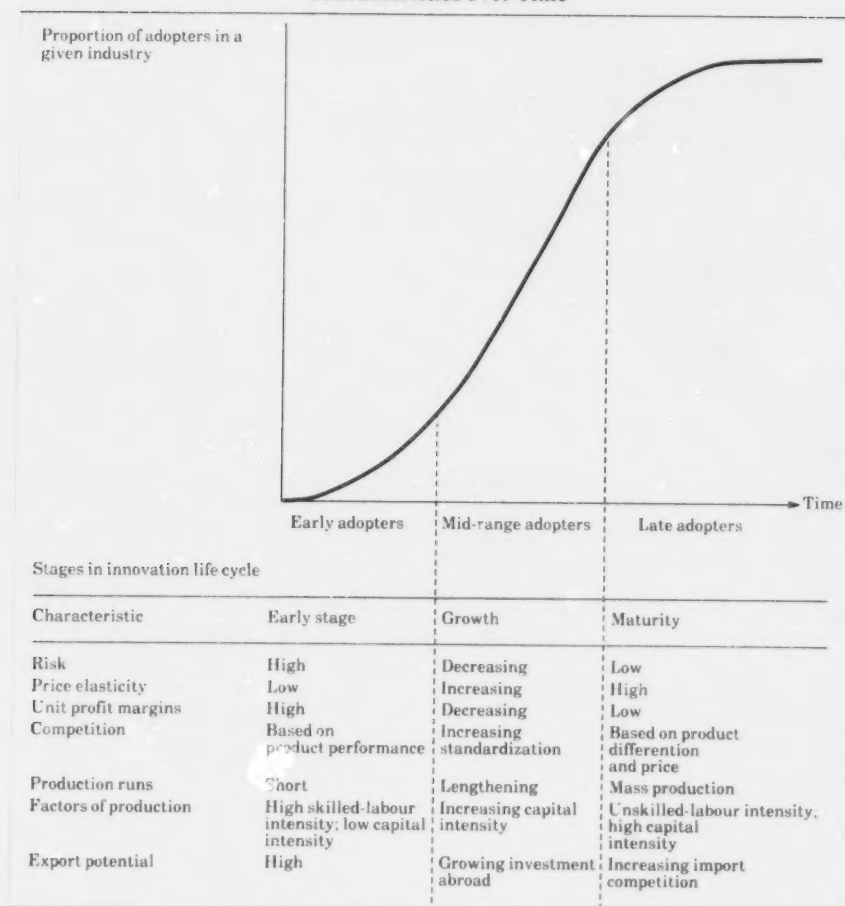
This evidence lends even more support to the findings of authors such as Mansfield and Globerman who stress the complementarity between diffusion and indigenous R&D. The point is that industries which spend relatively large amounts on R&D are more likely "to be close to the technological frontiers and able to imitate quickly" (Mansfield 1985, p. 82). These same industries are in a better position to trade technologies and to know what new technology to acquire.

Such observations have obvious implications for the policy debate concerning the relative benefits from subsidizing technology acquisition compared with indigenous invention. Although research indicates that the externalities associated with the R&D process are greater than with the technology transfer process, there may be a significant portion of spillover from the R&D process which accrues to foreigners. A further argument in this debate relates to the effect of the rate of diffusion on the innovation process.

Innovation and diffusion rates are inextricably linked. The diffusion process involves imitation. To the extent that it involves the support of imitation, the support of diffusion reduces the incentive to innovate (McFetridge and Corvari 1985, p. 224).

The importance of adopting new technology early is evident in the diffusion path in Figure 3.1. Early in the cycle, innovation carries a high degree of risk, which few firms are able to accept. Nevertheless, those firms that can successfully adopt the innovation are rewarded with high profit levels. As more firms innovate, the associated uncertainty, risk and profit all decline. Towards the end of the cycle, industry-wide knowledge about the innovation has reduced its risk, leading the remaining firms to adopt innovation rapidly. At this point industry profits will have returned to their normal levels. The diffusion cycle indicates the significance of early adoption. Early adoption is even more important when it generates economies of scale

Figure 3.1
Diffusion Path of Innovations and Changes in Their Life Cycle
Characteristics over Time



Source: Economic Council of Canada (1983) *The Bottom Line: Technology, Trade, and Income Growth*, p. 51.

that permit the innovator to capture permanently a large market share.

As Mansfield (1985) indicates, there are often considerable international differences in the rates of intra-country diffusion of an innovation. Such differences appear to be explained by the following factors: the variation among firms in the profitability of the innovation, the size of the investment required to introduce the innovation, the number of firms in the industry, their average size, the inequality of their size and the level of R&D expenditure.

Globerman's work on the rate of diffusion within Canadian industry indicates that some common characteristics emerge among early adopters. Although the direction of causality is sometimes unclear, it appears that early adoption is influenced by larger size, R&D expenditures, foreign ownership and some indicators of organizational receptivity to change. Globerman's findings also suggest that while management education is not necessarily a factor in explaining diffusion rates, other forms of education or the education level of other parties may be relevant. Other studies tend to confirm Globerman's observations although these put relatively more emphasis on the influence of the size of the firm as well as the profitability of the innovation.

It is stating the obvious to say that an innovation diffuses faster the more profitable it is and that it is adopted first by the firms finding it the most profitable. Profitability depends variously on wage rates, output mix, the nature of the existing production technology and the durability of productive assets. [The influence of firm or organization size does not prevail across all organization sizes]. However, to the extent that it does exist, it may reflect some or all of: a) the ability to diversify risk; b) economies of scale in information gathering; and c) the scale bias of the innovation in question (McFetridge and Corvari 1985, p. 188).

McFetridge and Corvari (1985) conclude, that despite its importance, early adoption should be regarded strictly as a means to an end. It is the efficient allocation of resources that is important and the point is that resources can be used inefficiently through premature adoption of new technologies just as easily as in other areas of economic activity. It is also important to realize that some of the factors at play in this process are exogenous (for example, factor endowments) while others can be affected by current or future public policy. Determinants such as market size, capital flows and information are directly related to trade, foreign investment and education policies and as such these

should be reconsidered. For instance, several authors (including Daly and Globerman 1976) have argued that Canada's small tariff-protected market has retarded both the initial and domestic diffusion of scale-oriented innovations. The openness of the economy to foreign direct investment is also significant for Canada given the considerable evidence that foreign ownership reduces international diffusion lags.

Canadian Evidence on Technology Diffusion

Much of the work comparing the rate of diffusion of technology in Canadian industry with that in the United States has been done by Globerman (1975a, 1975b, 1976, 1981, 1984). His general finding was that the process of technology adoption has been slower in Canada than in the United States. Globerman's earlier work on numerically controlled machines, tufting machines and special presses indicated international and domestic diffusion lags in the first two cases and an apparent domestic lag in the third.

In 1985, the Economic Council of Canada conducted its own survey (Working with Technology – WWTS) to assess Canada's record in the use of new technologies. The survey focused on computer-based technologies and included businesses of all sizes, in nearly all industries and in all regions. The survey results suggest that while much computer-based technology has been introduced by Canadian industries in the 1980s, the country is not progressing as rapidly as other industrialized economies (Japan, the United States, and Western Europe) in this respect. The main survey results are summarized below:

- Sixty-four per cent of computer-based innovations introduced between 1980 and 1985 fell into the office automation category; process automation technologies accounted for 23 per cent with the remaining 13 per cent consisting primarily of specialized computer applications.
- Within the manufacturing sector, process automation technologies accounted for 37 per cent of reported applications.
- The introduction of office automation was motivated mainly by the desire to increase productivity while the use of process automation was prompted as well by the possibility to improve product quality, to reduce labour costs, and to increase production control.
- Of the office technologies, personal computer work stations were the most common application. It is expected that the next major

phase of office automation (apparently already under way) will involve larger-scale, more sophisticated integrated networks.

- Computer-based process technologies diffused less widely than office automation technologies over the 1980-1985 period.
- Forty-three per cent of manufacturers reported the introduction of some type of process automation with 26 per cent introducing computer-aided manufacturing (CAM). However, fewer than 15 per cent of manufacturers introduced the other process technologies—computer-aided design (CAD), automated materials handling, computer numerical control (CNC), and automated inspection and quality control. Increasing rates of diffusion are therefore expected in the 1986-1990 period.
- The highest penetration levels for computer-based process technologies were evident in the machinery, chemicals, and electrical and electronics industries.
- The predominance of office over process technologies in the first half of the 1980s is explained in part by the differences in the relative cost of the technologies and in the degree of difficulty encountered during their implementation.
- Industries were ranked according to three measures of innovativeness: (1) according to the number of respondents reporting introduction of technologies, (2) according to the ratio of employees actually working with the technology, and (3) according to the ratio of expenditure on technology to total sales. Communications and other utilities, wholesale trade, finance, insurance, real estate and business services ranked high with respect to two of the measures. In manufacturing, the four highest ranking industries were printing and publishing; machinery; chemicals; and electrical and electronic products. Three industries scored very low on all three measures: leather, textiles and clothing; wood and furniture; and primary metals.
- Larger establishments were more likely to have introduced computer-based technology although the intensity of use was no greater in larger than in smaller establishments.
- Foreign-controlled firms were more likely than Canadian-controlled firms to have introduced computer-based technologies, and they also tended to have higher employee/use ratios. U.S.-

controlled firms had higher technology expenditure sales ratios as well.

More recent evidence reported by the Economic Council of Canada (1987) indicates that overall, Canada continues to lag behind a number of other Western industrialized countries in the development and use of new technology. For instance, Figure 3.2 demonstrates that in 1984, Canada ranked ninth out of 10 countries in the number of robots used per 10,000 workers employed in manufacturing—well behind Japan and Sweden. The OECD (1983b) has suggested that Canada may be experiencing a shortage of engineers and technicians trained in robotics. The Ontario Treasury Ministry (1984) points out that the slow diffusion of robot technology is disturbing because it is well suited to Canada's short production runs.

In the use of numerically controlled (NC) machine tools, Canada also ranked well behind Japan and the United States with 4.4 per cent of numerically controlled machine tools in use as a proportion of all machine tools in 1983. The corresponding rates in Japan and the United States were 38.1 per cent and 12.9 per cent respectively. Survey results also show that while Japan had 60 per cent of manufacturing establishments (with 100 or more employees) using some type of microelectronics equipment in 1982, Canada reached a similar level (58 per cent) only in 1985. As a result of much lower adoption levels among medium-sized, Canadian-controlled establishments, and among the largest Canadian and foreign-controlled establishments, the levels of adoption of microelectronic technologies in process applications were considerably higher in West Germany, Britain and France in 1983 than they were in Canada in 1985.

Table 3.1 reports the results from the DeMelto, McMullen and Wills (1980b) study of diffusion lags for imitative innovations in Canada. The data indicate that the average number of years between the first world launch or use of a product innovation and the first launch or use by the reporting Canadian firm between 1960 and 1979 was 7.4 years across industries, 1.3 years shorter than the lag for process innovations. The telecommunications industry did relatively well in both areas while smelting and refining industries rated the worst. The petroleum industry reported the shortest lag time for introducing product innovations and in process innovations, the electrical equipment industry came first.

Table 3.2 reports alternative estimates of the mean international diffusion lag for the period 1960-1979 as estimated by McFetridge and Corvari (1985). According to the authors, these figures suggest (1) that, in general, and in Canada in particular, the mean transfer lag is much shorter in the case of intra-corporate transfers as compared with

Figure 3.2
Robots per 10,000 Employees in Manufacturing, 1984



Source: Economic Council of Canada (1987). *Making Technology Work: Innovation and Jobs in Canada*. p. 5.

Table 3.1
Lags in the Introduction of Innovations Developed Abroad
into Canadian Industry, 1960-1979

Industry	Average Number of Years Between First World Launch or Use and First Launch or Use by Reporting Canadian Firm
Product Innovations:	
Telecommunications	5.5
Electrical equipment	9.3
Plastics and resins	7.5
Smelting and refining	10.3
Petroleum	5.0
Total	7.4
Process Innovations:	
Telecommunications	5.8
Electrical equipment	5.0
Plastics and resins	7.3
Smelting and refining	11.8
Petroleum	7.7
Total	8.7

Source: D. DeMelto, K. McMullen and R. Wills (1980b). "Preliminary Report: Innovation and Technological Change in Five Canadian Industries," Discussion Paper 176. Ottawa: Economic Council of Canada. p. 18.

arm's length transactions, and (2) that the average age of technologies transferred to Canada has been lower than the average age of technologies transferred to Western Europe. Other data on the year of first adoption and time lag after first adoption for a wide range of processes indicate that there have been some relatively long lags in several cases but also some closer to the mean as well as some shorter than the mean.

In many cases the difference in diffusion lags is attributable to technology-specific factors such as the suitability of the process and the required minimum scale. McFetridge and Corvari's analysis of these and other data relating the number of prior adoptions or

Table 3.2
Alternative Estimates of the Mean International Diffusion Lag,
1960-1979

	Mean Lag	Observations
		(years)
Multinational Enterprise Database		
Canada		
Intra-corporate	6.93	115
Arm's length	10.00	7
Both	7.11	122
Europe		
Intracorporate	10.27	340
Arm's length	10.86	116
Both	10.42	456
Rest of the World		
Intra-corporate	11.01	323
Arm's length	12.40	233
Both	11.70	556
Economic Council Database		
Canada		
Intracorporate	5.80	37
Arm's length	8.80	19
Both	6.94	56
Mansfield and Romeo		
Overseas developed countries ^a		
Intracorporate	5.8	27
Licensing/joint ventures	13.1	26
Less developed countries		
Intracorporate	9.8	12

Source: Estimates made by McFetridge and Corvari (1985) (Table 6.5, p. 191) using the Multinational Enterprises Database (see R. Vernon and W.H. Davidson, "Foreign Production of Technology-Intensive Products by U.S.-Based Multinational Enterprises," Working Paper (Boston: Harvard University Graduate School of Business, 1977) and the Economic Council Database (see D.P. DeMelto, K. McMullen and R. Wills, "Innovation and Technological Change in Five Canadian Industries," Economic Council of Canada Discussion Paper 176. Ottawa: The Council, 1980; E. Mansfield and A. Romeo, "Technology Transfer to Overseas Subsidiaries by U.S.-Based Firms," *Quarterly Journal of Economics* (December 1980): pp. 737-50.

a. Including Canada.

transfers, indicates that while there has been no decline in either transfer or imitation lag over the 1969-1979 period, "Canada's position in the transfer order has slipped." The authors argue that

[g]iven its privileged status with respect to U.S. technologies in the postwar period, Canada's position could hardly do other than deteriorate as a consequence of both the compression of the product cycle and the increase in the extent to which technologies diffuse internationally. This is apparently what has happened (McFetridge and Corvari 1985, p. 196).

Overall, it appears that the time lag between first foreign use and first Canadian adoption has been short by international standards. However, many observers indicate that it is the diffusion of new technologies within Canada that has been slow. "There are a number of instances in which new technologies have diffused more slowly within Canadian industry than within a foreign (usually American) counterpart. Among the factors which explain this are firm size and managerial incentives" (McFetridge 1986, p. 45).

Concern with the slow rates of diffusion within the manufacturing and service industries remains very much an issue in Canada. The view expressed by Daly and Globerman (1976) is that the tariff-protected Canadian market has resulted in small-scale production that prevents the acquisition of new capital equipment embodying the latest technology (because of fixed acquisition and installation costs). This point is also reflected in a more recent study by the Economic Council of Canada (1983). The problem, as characterized by the council, is that

... [new technology] diffuses slowly from firm to firm and from region to region within the country. By "new technology" we mean new and improved products, processes and organizational structures. Although there are some exceptions, case studies show that often the process of diffusion of technological change into and throughout Canada occurs more slowly than in other developed nations and not only in the manufacturing sector but in the service sector as well. Substantial benefits could be realized if the diffusion process into and throughout Canada were to be speeded up (p. 61).

The council points to tariff-induced short production runs as a major factor inhibiting diffusion. Technology policies aimed at encouraging the employment of domestic scientists rather than technological

progress are also perceived as a cause of this problem. This explains in part the council's support of further trade liberalization. The premise is that the producers who will survive the exposure to global competition will experience growth from improved access to foreign markets and innovation from the opportunity to specialize and spread the costs involved over a larger market base. The council also recommended that both the adaptation of new techniques from abroad and their diffusion within Canada be given more priority at the policy level. A similar argument appears in McFetridge's overview of the royal commission's research on the Canadian industrial structure.

New technologies may be scaled inappropriately for small firms If, as the discussion above on scale and specialization suggests, tariff reductions have the effect of increasing the length of production runs of Canadian firms, they may also have the added benefit of increasing the extent to which these firms can make use of the newest technologies and increasing the speed with which they can do so (McFetridge 1986, p. 45).

Technological Change and Employment

Technological changes are manifested in new instruments, products and processes, new organization of production processes, and new industrial structures which imply changes in the occupational structure and in allocations of the labour force. Technological change, in essence, involves what was described by Schumpeter as a process of destructive creation whereby the destruction of products, processes, skills, and jobs is offset by the creation of new products, processes, skills, and jobs.

The explanation for the positive employment effects on balance will be found in the productivity and growth effects of technological change The justification for investment in new instruments, processes, and products is in the greater efficiency which becomes manifested in lower costs and prices, higher incomes, and increases in demand and growth. Since the demand for labour is derived from the demand for goods and services labour produces, increases in demand for goods and services that exceed the increase in productivity will generate increases in employment (Peitchinis 1984, p. 35).

Although the adoption of the current and future generations of technology will have important economic consequences, there remains

considerable uncertainty concerning the net impact on the labour market. These concerns have sparked an ongoing debate. Some of the issues include the possibility of job loss, the de-skilling of jobs, the need for changes in education, training, and retraining.

The question of possible job displacement has been the focus of much attention. In Leontief's (1982) view, the spread of micro-electronics technology can only result in rising technological unemployment. The general concern appears to be centred on the likelihood that the manufacturing sector will shrink as a result of technology-induced productivity increases and the limited capacity of the service sector to absorb the unemployed. The issue of de-skilling, whereby new technologies appear to be adopted and adapted as part of "an overwhelming and apparently unavoidable trend towards work simplification" (Newton 1984, p. 236), is seen by many as also having far-reaching implications. The debate involves whether or not the initial de-skilling effects of certain technologies will give way to "re-skilling" as new production processes generate new functions. The de-skilling issue is related to the "declining middle class" argument advanced by Kuttner (1983). According to this argument, technological change alters the occupational distribution by upgrading some skills and downgrading others. This occurs in such a way as to erode substantially the middle levels of the occupational structure, and by the same token, the middle-income segment of the population. This argument coincides with the view that new technologies are instrumental in the shift from goods production (where many middle class jobs are held) to service activities (where a significant portion of the jobs are considered less attractive—low paying and part-time).

The latest research conducted for the OECD (1987) on information technology and economic prospects suggests that many earlier studies may have over-estimated the adverse effects on employment of new technology in general and microelectronics in particular. Whitley and Wilson (1987) identify four main factors which have contributed to the "potential over-estimation" of these effects. First, it appears that there has been a tendency to generalize inappropriately the results from particular case studies to the economy at large. For instance, some authors have applied the calculated productivity gains associated with technology adoption in large centralized office systems to the whole sector. The second reason involves the over-optimistic attitude that has been adopted regarding the rate of diffusion of the new technology. To appropriate the potential benefits of new technology requires prior investments in both physical and human capital. These economic constraints tend to slow down the rate of diffusion. The less rapid than anticipated rate of introduction of new process technologies (CAD/CAM) is an example of

this. The third reason also concerns attitudes that certain technological developments, in microelectronics for instance, have been regarded as revolutionary rather than evolutionary. However, evidence suggests that the marked acceleration in the pace of improvement in productivity necessary to directly displace labour to a degree that is noticeably different from the previous generations of technology is very unlikely to materialize. Finally, perhaps the most important factor is the overemphasis on the direct displacement effect of technological change on employment and the failure to acknowledge the importance of a number of compensatory factors which tend to offset the displacement effects by causing output levels to increase. These compensatory factors can result in any or all of the following effects:

- increased domestic demand resulting from higher real incomes;
- increased foreign demand resulting from improved price and non-price competitiveness;
- increased demand for investment goods in order to implement the new technology;
- dynamic effects, such as the multiplier effects, on real incomes following increases in autonomous expenditures;
- equilibrating effects in the labour market.

It is therefore essential that the indirect effects on intermediate demands and components of final demand be considered in order to quantify the possible impact of technology. The results from the OECD (1987) research program tend to confirm the view that the diffusion of information technology is generating employment shifts from manufacturing activities to services. This implies a change in skill requirements but is not expected to provoke the mass destruction of jobs.

One might thus expect to see employment share decreasing in the manufacturing sector and increasing in the service sector. The growth in the service sector will mainly be based on services for the production, use and marketing of IT based goods and processes (high-tech services). This suggests the appearance of many new products in the market in every sector. Perhaps the major difference between manufacturing and services is that the manufacturing sector tends to be traded more intensively

than the products in the service sector (although there are tendencies towards greater trade in services). This suggests that in the manufacturing sector, to a greater extent than in services, it is rates of advance relative to international competitors that will determine an individual country's output and employment level. However, this consideration will also be relevant to those service industries that are particularly intensively traded (OECD 1987, p. 16).

Whitley and Wilson (1987) also see the rate of diffusion as the element which may, to a great extent, determine the potential outcome in terms of employment.

... a key issue is the rate at which the new technology is introduced in a particular country relative to the rate of introduction of its main competitors. The outcome of this will impinge on trade performance, not just through the obvious impact on relative costs and prices, but also through changes in the non-price aspects such as quality, versatility, and the introduction of new products. Indeed, once one takes a more comprehensive view it becomes clear that (at least over the next 10-15 years) the major impact on employment levels may result from the differences in the rate of adoption of microelectronic technology which thereby affect the international distribution of employment, rather than any direct impact within the country concerned (Whitley and Wilson 1987, p. 183).

These observations underline the importance of education and training policies. These are seen as increasingly relevant in two respects: first, there is ample evidence that the lack of suitably qualified personnel can slow the development and diffusion of new technology and, second, the process of technological change involves the generation of new skill requirements and functions, as well as the elimination of others through redundancy. It is argued that "only by retraining and re-educating can the labour market be made to learn more quickly" (OECD 1987, p. 60). Because of the many problems associated with the forecasting of future skill and educational requirements, the primary concern at the policy level should be to provide a labour force that is adaptable and flexible "... [if] one cannot predict future movements in the skill composition of labour demand, having the ability to respond quickly and to realize outcomes, will be the most valuable asset" (OECD 1987, p. 61). This approach, which is

seen as the appropriate course of action for Canada, is the subject of Part C of this book.

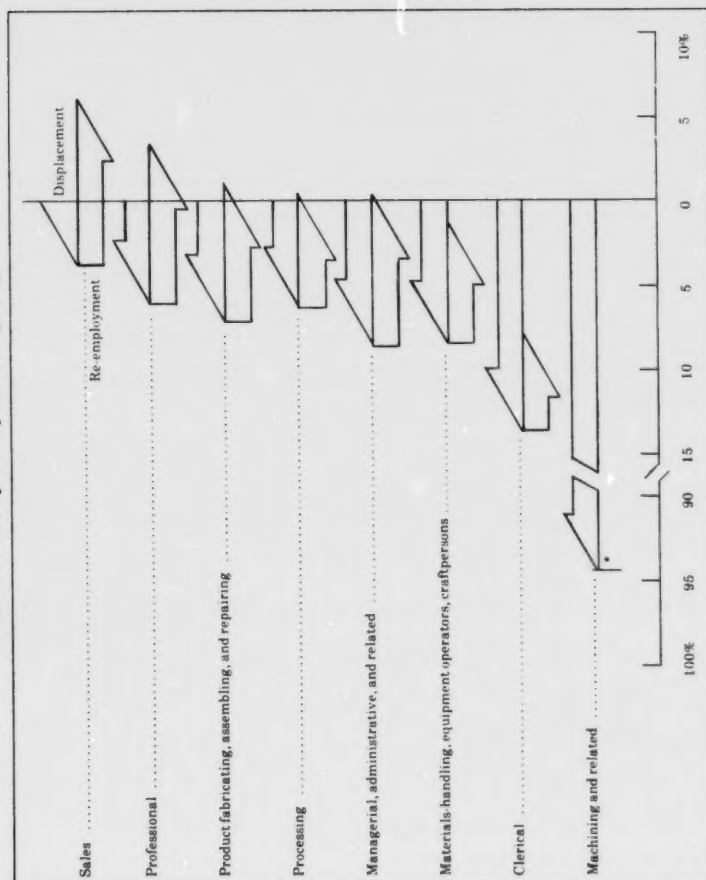
The Economic Council of Canada (1987) report on recent changes in the structure of Canadian employment reflects some of the consequences of technological change for the Canadian economy thus far. A distinctive feature of this study concerns the definition of the high-tech sector which has been broadened to include not only the producers, but also the users of high technology (based on the proportion of intermediate inputs that is made up of high-tech inputs). Among the high-tech industries are motor vehicles; communications; finance, insurance and real estate; and commercial services. The following is a summary of the main findings:

- Between 1971 and 1981, the positive effect of productivity growth on incomes was substantially larger than its negative impact on employment. The net result was a 30 per cent growth in employment in Canada over the decade.
- Over the same period, increases in the demand for skills associated with high-tech occupations resulted in high rates of employment growth for these occupations. Low-skill occupations on the other hand saw the demand for their skills diminish. The net effect was employment growth in most occupations.
- The direct employment effects of technological change account for employment growth in 43 per cent of all occupations, employing 36 per cent of all workers.
- Some completely new occupational classifications have appeared (computer-aided design draftsmen) while others have been renamed to reflect new skills or tools performed or used by more or less the same people (word processor operators). Some classifications have disappeared altogether (elevator starters, switch repairmen).
- The high-tech sector (producers and users) experienced higher rates of employment and output growth throughout the 1970s and 1980s than did the mid- and low-tech sectors. The rate of output growth was sufficiently high to offset the negative impact of productivity growth on employment with the net result that employment in this sector grew as a proportion of all employment. Figures suggest that this employment growth slowed down somewhat in 1981-1985. Analysis indicates that the strongest influence on employment growth was sales growth itself.

- No concluding evidence of a declining middle class has been found. For the period 1971-1985, respective shares of income have been remarkably stable. During the period 1971-1981, the high-tech sector generated the bulk of all jobs in the economy and contributed even more strongly to the growth of middle-income jobs. The fastest growing jobs were high-skilled jobs, while the jobs in fastest decline were the low-skilled ones. However, it is cautioned that in many respects we are only at the early stages of the current wave of technological change and furthermore, that Canada is lagging behind in the application of many of these technologies. Some concern is also expressed over the fact that Canada is facing growing competition, not only in the high-tech sector from the newly industrializing countries, but also in its areas of comparative advantage such as the supply of certain natural resources.
- Two sources of employment projections are reported. According to the Canadian Occupational Projection System Model (COPS), sales and service occupations are expected to be among the fastest growing occupations, while occupations in textiles, farming, fishing, product fabricating and assembly are expected to be in the fastest declining group. The high-tech share of total occupational employment is expected to remain fairly constant.

The results of the Economic Council's Microelectronic Simulation Model, incorporating computer-based technological change, are reported in Figure 3.3. The results serve to illustrate how the pattern of employment will differ depending on the rate of diffusion and the adjustment response. The results indicate that (1) the impact of technological change is highly uneven across occupations, (2) it has the potential to cause considerable worker displacement, and (3) the indirect employment generating effect arising out of the productivity payoff can be large. Such indirect positive effects more than offset the displacement effects in sales, in professional occupations, in product fabrication, assembly and repair, in processing, and in managerial, administrative and related occupations. Occupations such as machining and clerical occupations may, however, experience considerable net job losses. As the Economic Council report indicates, the full extent of the displacement or re-employment may not be realized. "Where Canadians will end up between these two limits will depend on how well they retrain and adapt. Everything Canada does to foster the effective use of new technologies will bring it closer to full re-employment of the workers displaced" (Economic Council 1987, p. 12).

Figure 3.3
Projected change in Canadian employment to 1995, relative to
1981 levels, by occupational group



Source: Economic Council of Canada (1987) *Making Technology Work: Innovations and Jobs in Canada*, p. 13.

Conclusion

The purpose of this chapter was to describe the process and properties of technological change, analyze the patterns which are emerging in the international context, and examine Canada's record as a producer and user of new technology. The important issue of the impact of technological change on employment was also discussed. The following observations are made:

Technological change is a complex phenomenon consisting of three inter-related stages: invention, innovation, and diffusion. The introduction of new technology can lower production costs or enhance product quality. This in turn leads to a series of complex reactions which can affect input demand, prices, product demand, output, and income.

Two properties in particular help explain the level of interest in product and process development activities: spillovers which are incidental benefits that can accrue to individuals, firms, or nations with no corresponding compensation provided to those who generate the externality; and learning curves, a term used to describe the relationship between production costs and accumulated production volume. By being the first to enter the market, a firm can build up sufficient production volume to lower unit costs, thereby gaining a "sunk" or market-specific asset which will deter competition and may enable the firm to generate above normal profits.

Studies indicate that technology is an important factor in explaining productivity growth; however, the effect tends to vary over time and between industries.

In many instances the indirect effects of technology that occur, for example, through input purchases are more significant than the direct effects with respect to productivity growth. This observation emphasizes the importance of the linkages between the producers and users of new technology.

There are indications of an overall reduction in the pace of technological change since the 1970s and a weakening of the U.S. position as the dominant source of innovations relative to other countries.

As a source of technology Canada is a small player, creating only 0.3 per cent of the world's patented inventions and undertaking relatively less R&D than other OECD countries. Canada, therefore, depends largely on foreign sources for the technology it requires, and in so doing, is one of the world's most important recipients of foreign technology; for instance, it grants the third highest number of patents to foreigners after the United States and Britain.

Research shows that innovations originate mostly in a few countries (the United States, Japan, France, West Germany and the United Kingdom) and in a few industries. These same industries provide the greatest fraction of their technological requirements but

they also are the major users of new technology from external sources. This observation and other findings emphasize the importance of R&D as a factor in the diffusion process. Industries that undertake R&D activities are more likely to be aware of which technologies to acquire and to be able to adopt and adapt these for their own purposes.

Other factors, such as the profitability of the innovation, the firm's size and foreign ownership, are also directly related to early adoption of new technology. It appears that, in general, the time lag between first foreign use and first Canadian adoption has been short by international standards although it has been suggested that Canada's position in the transfer order may have slipped in recent years. Many observers argue that it is the diffusion of new technologies within Canada that has been slow. Studies suggest that Canada's tariff protected market has been a major factor inhibiting diffusion because of the resulting small scale and short production runs. On the other hand, foreign ownership and the intra-corporate transactions it involves, appear to be associated with relatively shorter technology transfer lags for Canada.

The most recent evidence suggests that, overall, Canada continues to lag behind a number of other Western industrialized countries in the development and use of new technologies, including robots, numerically controlled machine tools and other types of micro-electronics equipment, particularly process technologies. Indications are that the relative cost of these technologies and the degree of difficulty associated with their implementation are important factors in explaining this situation.

The process of technological change renders certain products, processes, skills and employment obsolete. This obsolescence comes about as new products and processes are introduced which in turn generate a demand for new labour skills. The net impact on employment levels is determined by the productivity and growth effects of technological change. It appears that in analyzing the impact of technological change on the labour market, many observers have a tendency to overemphasize the direct displacement effects and have failed to acknowledge appropriately the number of compensatory effects which cause output levels to increase, thereby offsetting the direct effects. It is clear, however, that technological change has the potential to alter the industrial structure and the mix of occupations within industries and, therefore, may lead to shifts in the occupational structure of employment. The key elements in determining the net employment outcome are the rate of diffusion of new technologies, the adaptability and flexibility of the labour force, and the industrial structure. This emphasizes the importance of education and training policies as a means of decreasing barriers to technology diffusion and facilitating economic adjustment.

Chapter IV

Information Technology

Introduction

The current literature on technology abounds with descriptions of how the world economy is moving into the Information Age. The magnitude of the underlying shifts in industrial structure is being compared with those that occurred during the Industrial Revolution. Commentators emphasize the increasing role of information as a key variable in the production process. This phenomenon is seen as technology driven and as gaining momentum. For instance, a 1987 study by the Organization for Economic Cooperation and Development (OECD) estimates that as much as 80 per cent of current and medium-term future technological advances will be information technology-based. The study, based on evidence on the diffusion of innovations using information technology (IT), suggests that only 10 to 20 per cent of potential applications have been achieved and that a much larger impact can be expected in the near future. Because information technologies have applications in a variety of industries, it is predicted that they will have the most wide-ranging effects on the structure and composition of employment. Finally, perhaps the single most important property of IT-based technological change is that the technologies have proven to be "enabling" in the sense that they can be regarded as "a tool that permits rapid change in other fields" (Economic Council of Canada 1987, p. 2).

This chapter is divided into two sections. The first section examines the particular characteristics of the information technology

sector and discusses the likely patterns of development and economic prospects in this area. The second section presents a statistical overview of the information technology sector in Canada. This overview provides a general indication of the relative size and performance of the sector over the last decade.

Technology Applications and Merging Sectors

The 1987 OECD study refers to information technology as the broad spectrum of technologies used in the collection, processing and transmission of information. Information technology includes micro-electronic and opto-electronic based technologies that are incorporated in many of today's products and production processes, and that are increasingly affecting the service sectors. These include: computers, electronic office equipment, telecommunications, industrial robots and other computer controlled machines, electronic components, and software products. The Economic Council of Canada (1987) points out that not only have these technologies evolved rapidly, they have diffused widely and are highly visible. The dynamism exhibited in this sector can be explained by the characteristics of IT-innovations as they have evolved in the past decades. These are described by Irwin (1984):

A first observation is that the productivity of technology – whether in satellites, computers, telecommunications, fiber optics, or integrated circuits, is increasing and unremitting. The semiconductor industry reminds us that the number of components per silicon chip has doubled annually for the past twenty years.... Subsequent generations yield five to ten times the capacity of previous hardware. A submarine cable today generates a capacity of 4,000 voice circuits. TAT-8, a new transatlantic fiber optic cable will enjoy a capacity of 40,000 voice channels. Still newer generations of equipment are on the horizon.

Second, productivity translates into declining unit costs.... A \$295 VCR today cost \$75,000 in 1959. A \$2,600 facsimile machine today cost \$21,000 five years ago. A \$2,000 satellite receiving dish today cost \$10,000 in 1980. Although costs do not drop forever, there is little indication that the interplay of productivity and unit costs will be disrupted in the foreseeable future.

Third, the range of information technology is diverse and expanding. That diversity invites product combinations. No one has coined an appropriate term to describe this

technological coupling, but users can blend, combine, and match satellites, fiber optics, computers, software, PBXs, digital equipment, coaxial cables and local area networks.

Finally, productivity, unit costs, diversity and coupling are no longer confined to one firm, one industry or one economy. Technology has diffused and migrated, occurring in the Far East, North America, and Europe (p. 14).

A notion of the diversity and expansion of information technology can be obtained by examining a list of the technologies involved alongside a brief description of their applications. In 1985 the Ontario Task Force on Employment and New Technology examined the range of technologies most likely to generate substantial changes in employment over the 1985-1995 decade. It was concluded that office automation technologies, telecommunications, computer-based technologies, and advanced manufacturing have the greatest potential to create these employment changes. The list of selected technologies and selected applications categorized in these four groups is reproduced in Table 4.1. The striking feature of this table is the wide spectrum of applications and the interlinkages between the various technologies.

The evolution and expansion of information technologies in their applications, usage, and associated "technological coupling," has resulted in the "gradual blurring of traditional distinctions between computers, telecommunications, and other information industries" (Paul 1984, p. 52). These previously distinct industries are experiencing a merging phenomenon whereby... "computers, communications equipment, and electronic components are increasingly integrated into one industrial complex, spurred on by the continuing, rapid advances in electronics technology" (Flamm 1987, p. 7).

As the list of technologies and applications in Table 4.1 suggests, it will be increasingly difficult to distinguish between the products of these individual industries.

Two decades ago, a telephone, a computer, a copier, a PBX, a TV set, or newspaper, appeared as separate entities. Today such an identity is softened. The latest telephone embodies a handset, a CRT and a printer, a blend of the new and the old. Today's nomenclature suggests the blurring of product boundaries. A typewriter is a word processor; a PBX—an information switch; a copier—a document distributor; a TV set—electronic publishing; a cash register—a point of sales device; a computer—a work station (Irwin 1984, p. 16).

Table 4.1
Selected Technologies by Technology Group

Selected Technologies	Selected Applications
Office Automation Technology	
Word Processor	Preparation, modification and printing written documents
Microcomputer and Personal Computer	Data analysis, manipulation and storage, graphics and word processing
Electronic Filing System	Large-scale document storage
Fully Integrated Work Station	Multi-function word and data processing, microcomputer, and voice and data terminal
Local Area Network	Linkage of microcomputers so that data and software can be shared
Internal Data Base Management Systems	Organization and collection of data for various management purposes.
External Data Base Services	Provision of information and data from external sources.
Telecommunications Technology	
Private Automated Branch Exchange	Telephone switching, call forwarding, call monitoring, cost tracing, voice mail
Electronic Mail	Inter-office mail, memos, documents or reports
Video Conferencing	Remote meetings include full or partial video link, audio and data transmission
Fiber Optics	Broadband, high capacity telecommunications links, secure telecommunications facilities
Head Office/Plant Computer Lines	Exchange of data, electronic mail, reports, memos between regionally dispersed operations
Head Office/Customer Computer Links	Sales ordering, inventory monitoring, sales trends analysis
Videotex (Telidon)	Transmission of text or graphic information over telephone lines to normal television set equipped with special decoder

Table 4.1 (cont'd)

Selected Technologies	Selected Applications
Facsimile Transmission	Transmission of document copies
Dedicated Satellite Systems	Long-distance communications between regionally-dispersed offices
Computer-Based Technology	
Very Large-Scale Integrated Circuits	Microprocessor and memory components
Supercomputer	Long-term weather forecasting, large-scale data analysis, cryptography
Artificial Intelligence	Robotics, advanced machine tools, pattern recognition, computer aided design/manufacturing, computer aided engineering
Expert Systems	Diagnostic and decision support systems in mining, medicine, law, accounting and engineering
Fourth Generation (Natural) Programming Languages	All present software applications
Voice Synthesis/Recognition	Selected input and output applications
Point-of-Sale Scanning Equipment	Retail sales data input, monitoring inventory
Electronic Funds Transfer System	Finance, banking and retailing
Smart Cards	Retailing, banking
Automated Teller Machines	Banking, retailing
Computer Decision Support Systems	All management areas
Customer Sales and Service Systems	Systems for delivering information services directly to customers
Advanced Manufacturing Technology	
Computer-Aided Design (CAD)	Design, drafting, layout of manufactured products, piping, electrical or electronic circuits
Computer-Aided Engineering (CAE)	Engineering analysis and design
Computer-Aided Manufacturing (CAM)	Systems for storing and transmitting instructions between computer systems and various manufacturing tools

Table 4.1 (cont'd)

Selected Technologies	Selected Applications
CAD/CAM Integration	Combines functions of both technologies above so that data from CAD can be directly transmitted to machine tool instructions
Computerized Numerically-Controlled Machine Tools	Machines tools re-programmable locally or remotely
Robotics	Pick and place, machine loading/unloading, spot welding, spray painting, palletization, assembly, fabrication
Manufacturing Resource Planning	Resource planning, ordering, monitoring and control
Automated Shop Floor Data Collection Systems	Collect data from production for other management purposes
Computerized Decision Support Systems	Assists management production, planning and design making
Computerized Order Entry Inventory Control	Uses sale orders to initiate work orders and monitor work in progress
Computer-Aided Inspection and Testing	Inspection and statistical quality control in all manufacturing areas
Computer-Integrated Manufacturing	Fully integrated advanced systems with CAD, CAM, and many have CAE, shop floor data collection, inventory control, resource planning facilities
Flexible Manufacturing Technologies	Small-to-medium scale batch production, allows rapid retooling and multiproduct production on same production line - customized on off products
Computerized Process Control systems	Monitors and controls continuous process operation
Automated Storage and Retrieval Systems	Automated conveyor and vehicle systems for inventory storage and material handling

Source: Ontario Task Force on Employment and New Technology, *Employment and New Technology*, Toronto: Queen's Printer 1985.

The blurring of product demarcations is basically the consequence of an overlap in functions and form as technological change proceeds. Bell makes reference to "the growing interconnection between computers and telecommunications" (Bell 1980, p. vii). Computers can simulate; but just as important, they can receive, store, retrieve and send data. Thus the distinction between the functions performed by computers and telecommunications systems are blurred. The functional distinctions between robots and computers, and robots and telecommunications systems, are also vanishing with the increasing sophistication of production and inventory methods. There has been a concurrent expansion in the computer management of production, using a central command computer to send instructions to production areas and receive data on the output being produced. The computer managing the operation can be separated geographically from the area where production occurs and it is often linked directly to robots under its command. Thus computers, telecommunications and industrial robots are becoming functionally less distinct.

Essentially, robots are mechanical devices coupled with electronic command units that are actually computers themselves. In fact, because the basic component of all computers, telecommunications systems, and robots is the electronic circuit, the products of these sectors cannot be distinguished on the basis of form either.

Not surprisingly, it has become difficult to study these industries as separate entities. Each sector is interconnected and feeds on the developments achieved in others.

... consider telecommunications. Yesterday's telephones were regarded as natural monopolies. Today, the telecommunications industry is inhabited by telephone carriers, resellers, satellite carriers, commercial banks, courier services, and aerospace firms. As industries converge, borderless markets erupt as a new economic reality in a traditionally regulated industry (Irwin 1984, p. 16).

A similar transition is taking place in services. Studies concerning services and the development process were undertaken by the United Nations Conference on Trade and Development (UNCTAD) (1985, 1986). They emphasize how the adoption of information technologies has been instrumental in increasing the transportability or tradeability of services through the development of world-wide information "grids" and telematics. Information technology-based innovations have enabled the provision of a wide array of services on a worldwide basis, from traditional ones such as shipping and insurance to new ones, such as data processing and computer-assisted design. Because the incremental costs of adding services which are

information based are very low once the grid is built, there will continue to be an expansion of the variety of services being offered by individual service industries (for example, non-banking services offered by banks and *vice versa*). In the process, these technological developments have significantly reduced geographical constraints, particularly the constraints to production. As a consequence, the scope for operation of multinational enterprises has been increased along with their competitiveness in the world economy.

Transborder data flows have become the "life blood" of transnational corporations, leading not only to a greater tradeability of services, but also to the facilitation of production of services in foreign subsidiaries abroad. . . . While information has always been paramount in the production of many services, it has greatly increased in importance in recent years. This has been due to the exponential increase in the ability to store, process and transport information and to the fact that information can not only be "stored" in goods but also "embodied" in them. . . . Technological advances are reducing the extent to which capital or people are required to move relative to services embodied in goods or as information. . . . Competitiveness in services now accrues to those who possess both the information and the means of transmitting it across borders and as was noted, these tend to be the transnational corporations (UNCTAD 1985 and 1986).

The long-term implications of advances in information technology may be rooted more deeply. There are suggestions that information processing is gaining importance as "soft capital" within the firm. Information is viewed from this perspective as a direct input into the production process, and the firm is viewed as an organism increasingly engaged in the processing, collecting and transmitting of information rather than materials.

New information technologies also have the potential for synergistic gains that will generate more dramatic impacts when some critical stage in development or diffusion is attained. For instance, facsimile machines will continue to spread slowly until a user has a significant number of recipients with such machines. Another example relates to the speed of transfer of data and other materials which will reach its potential when the capacity constraints of telephone lines are lifted.

However, the most consequential changes are expected to occur as a result of the economic adjustments brought about by IT innovations.

In the longer term also, as more information technology is introduced, intelligent reprogrammable machines may become the norm rather than the exception. This may imply changes in the production process that cannot adequately be treated as capital or labour saving. More use of these technologies will generate more just-in-time systems, automated warehousing, CAD/CAM systems, etc., that have major impacts on required levels of inventories and work in progress. They will also mean greater flexibility in manufacturing and the possibilities of more high quality, custom-tailored, small batch production at economic cost.

... In the 50/60/early 70s, demand growth was accompanied by production expansion largely based on large firms reaping the benefits of scale economies in producing large quantities of standardized products. In the future, a different scenario may emerge – the new technology makes more customization possible, smaller batches and greater production flexibility. The scale benefits are no longer so important, smaller scale industry is economically viable and perhaps more dynamic. The capital savings bias of IT reported on earlier, might indeed support such trends to "smallness" and the productivity gains to be forthcoming with such trends. Associated with this might be less centralization, more decentralization, perhaps even a general relocation of industry in the very long term. This relocation may even involve international relocation on a broad scale (OECD 1987, p. 23).

Baranson (1986) also underlines the compatibility between the evolutionary changes in the world economy and the evolution of information technologies that lead to flexible (reprogrammable) manufacturing systems. The expected outcome of these developments is that economies of production will increasingly be linked to scope rather than scale. "Scope implies an ability to move rapidly and cost effectively into multiple configurations, components and end products in response to successive changes in demand and production factor costs" (Baranson 1986, p. 413). The following examples give an indication of what this restructuring may imply for labour and productivity.

- *Hughes Aircraft* installed an FMS that consists of nine integrated machining centres which have replaced 25 stand-

alone machining centres. The new facility represents 75 per cent of the previous facility's investment costs and has reduced machine time by 90 per cent and labour costs by 87 per cent.

- *Vought* installed a \$10 million facility that can turn out 600 different designs in random sequence. Savings ran \$25 million in machining costs, and labour hours have been reduced by two thirds.
- *Ingersoll Milling Machine* installed a fully integrated system linking process control to highly variable changes in output demand. The system will machine 25,000 different prismatic parts (70 per cent are single items) at unit costs that are near that of long production runs—an invaluable asset in the specialty machining business.
- *Mazak (Yamazaki)* machine tool plant in Kentucky is a completely integrated FMS facility that fabricates 180 different parts (varying from a few pounds to three tons). Delivery time on ordered machine tools is 30 days—as compared to the six month norm for the industry.
- *General Electric's* FMS facility manufacturing locomotive diesel engines has reduced completion time from 16 days to 16 hours (Baranson 1986, p. 413).

In Baranson's view, the relocation of industry resulting from these changes may not necessarily lead to more decentralization. The author argues that the new manufacturing technologies will require a strengthening of both the external and internal linkages of the firm. Direct contact with customers is necessary to enable the tailoring of products to end-user demands and to assist in the use of systems that are increasingly complex. Improved internal linkages involve the coordination of design, engineering production and marketing functions to foster the delivery of more complex, diverse, and high quality products in shorter time spans. This is likely to result in a reduction of offshore assembly, together with new labour requirements, particularly for highly skilled labour capable of adapting rapidly to new tasks. These observations also underline the growing importance of services within the manufacturing sector. Baranson predicts that capturing the higher priced, low volume demand niches may be the best competitive strategy for Canada to adopt. Generally speaking, those products which have to be custom tailored or require either pre-sale consultation or after-sale servicing are more likely to be successful for Canadian enterprises.

The Information Technology Sector in Canada: A Statistical Overview

The purpose of this section is to present a broad statistical overview* of the information technology sector in Canada so as to provide a general indication of the size and performance of the sector over the last decade.

For the purpose of this overview, the sector is defined to be the industries listed in Table 4.2. The realities of data collection unfortunately imply that any practical listing of sector products must exclude some relevant products while including others that should not be counted. For example, insulated telephone cable—in Standard Industrial Classification (SIC) category 3381—might be included, while it is not clear that sonar equipment—in SIC 3359—is actually a relevant information technology product. However, indications are that the problem of excluded relevant products is probably not too severe.

Statistics Canada data are gathered in an annual census of establishments. An establishment is defined as the smallest unit which is a separate operating entity capable of reporting the following:

- Materials and supplies used
- Goods purchased for resale in same condition as purchased
- Fuel and electricity consumed
- Number of employees and salaries and wages
- Man-hours of employment
- Inventories
- Shipments or sales

Small firms are assigned an SIC category on the basis of their major activity. If a firm's major activity is manufacturing while it also purchases other products for resale, then that firm is classified as a manufacturer and its resale activity is indistinguishable from its manufacturing activity. Large firms are asked to respond on a divisional basis and each division is classified separately. Hence, manufacturing and, say, resale activity can be classified separately if a firm is able to allocate those activities to separate divisions. Because many firms report on a divisional basis, the number of establishments approximates but overstates the number of firms in each SIC category. It should be noted that the SIC categories comprising the information technology sector focus on manufacturing and services, to

* This overview has been written by John Henderson, a research associate with the Institute for Research on Public Policy.

Table 4.2
The Information Technology Sector in Canada

1980 SIC Designation	1970 SIC Equivalent	Description
335	335	Communication and Other Electronic Equipment Industries
3351		Telecommunication Equipment Industry
3352		Electronic Parts and Components Industry
3359		Other Communication and Electronic Equipment Industries
336	318	Office, Store and Business Machine Industries
3361		Electronic Computing and Peripheral Equipment Industry
3362		Electronic Office, Store and Business Machine Industry
3369		Other Office, Store and Business Machine Industries
482	544, 545	Telecommunication Carriers Industry
772	853	Computer and Related Services
7721		Computer Services
7722		Computer Equipment Maintenance and Repair

Source: Statistics Canada (1980).

the exclusion of wholesale and retail trading activities because Statistics Canada data do not break out wholesale and retail sales of information technology products in useful detail. Rather, they are included in very broad categories such as SIC 5743 – Electronic Machinery, Equipment and Supplies, Wholesale.

We begin with a summary of overall Canadian economic activity that is used to compare aggregate statistics for the information technology sector. Finally we report data at the three-digit and four-digit SIC levels, which provide additional information about each industry group comprising the sector. Overall, we find that in the context of the Canadian economy, Canada's information technology sector is young, important and growing very rapidly.

Table 4.3 provides a summary of overall Canadian economic activity as a basis for evaluating the growth of the IT sector. Between 1976 and 1985 nominal gross national product (GNP) grew at an annual compound rate of 10.3 per cent, while the GNP deflator rose at the compound rate of 7.5 per cent. Therefore real GNP grew at a rate of about 2.8 per cent. The growth rate of employment was 2.0 per cent so that economy-wide output per worker increased by 0.8 per cent annually over the period. The nominal wage per worker grew at a rate of 9.6 per cent between 1976 and 1985, and real wage increased by 2.1 per cent to about \$22,400 (in 1985 dollars).

Table 4.3
The Overall Canadian Economy

	Employment	Wages and Salaries	Nominal GNP	GNP Deflator
	'000 persons	\$million		1985 = 100
1976	9 477	110 419	191 857	52.0
1977	9 651	122 476	210 189	55.9
1978	9 987	133 383	232 211	59.6
1979	10 395	150 172	264 279	65.7
1980	10 708	169 736	297 556	73.2
1981	11 006	196 002	339 797	81.7
1982	10 644	209 449	358 302	90.0
1983	10 734	219 352	389 844	93.4
1984	11 000	235 903	420 870	96.8
1985	11 311	252 815	461 764	100.0
CGR(%)	2.0	9.6	10.3	7.5

Source: Statistics Canada 11-003E and 13-201.

Table 4.4 presents some aggregations for the information technology sector as a whole. Between 1976 and 1984 the number of establishments rose from 1,683 to 2,948 for a growth rate of 7.3 per cent (Note that the aggregate number of establishments does not approximate the aggregate number of firms here; the problem of double counting is likely to be severe because many firms are horizontally integrated across this sector). Data on the birth and death rates that generate the observed growth in the number of establishments are not available. Industry experts confirm, however, that the sector exhibits a healthy process of natural selection as firms that lose their competitive position are replaced by new vigorous producers. Between 1976 and 1984, sector employment grew somewhat faster than employment economy-wide. Data are not available at the level of individual firms but interviews with industry officials suggest that most employment growth is being generated by small firms. Employment totalled 203,587 workers in 1984 and this was 1.9 per cent of the Canadian total. Wages and salaries also grew faster, equalling \$6.1 billion in 1984 (or 2.6 per cent of the total for the economy). A rough measure of sector output puts the total at about \$18.8 billion, equal to 4.5 per cent of GNP.

Table 4.4
Summary Statistics for the Information Technology Sector^a

	Establishments	Employees	Wages and Salaries	Total Productive Activity ^b
	number		\$thousand	
1976	1 683	157 874	2 328 579	6 607 091
1977	1 255	159 892	2 539 918	7 336 305
1978	1 385	169 550	2 877 607	8 422 569
1979	1 400	178 741	3 384 618	9 858 830
1980	1 745	190 300	3 960 961	11 766 073
1981	2 076	201 784	4 788 856	14 319 153
1982	2 468	205 849	5 403 857	16 288 336
1983	2 576	195 818	5 547 823	16 441 209
1984	2 948	203 587	6 092 843	18 787 871
CGR(%)	7.3	3.2	12.8	14.0

a Defined as the industries comprising SIC 335 + 336 + 482 + 772.

b Equals shipments of goods of own manufacture for SIC 335 + 336 plus operating revenue for SIC 482 + 772.

Source: Tables 4.5, 4.10, 4.14, 4.16.

Tables 4.5 and 4.6 present information about establishments designated to Communications and Other Electronic Industries (SIC 335). Table 4.5 indicates that in 1984, 476 establishments shipped \$3.8 billion of goods of own manufacture. Thus each firm shipped over \$8 million on average (Table 4.6). The number of establishments expanded at a compound rate of 7.8 per cent between 1976 and 1984, indicating that a large number of new firms entered the industries. Employment grew at the rate of 3.8 per cent per year, about double the rate for the economy as a whole. Real wages grew over the period to close to \$27,000 (in 1985 dollars) which is about \$4,800 above the national average. Value added in the industries equalled \$2.7 billion in 1984 and nominal value added per employee grew at an annual rate of 9.6 per cent. Limited price data suggest that output price rose at about 3.5 per cent per annum so that real value added per worker rose annually at about 6 per cent compared with about 0.8 per cent throughout the entire economy. Pre-tax profit as a percentage of total income varied around an average of about 4.7 per cent, compared to 4.4 per cent for all manufacturing.

Data on Communications and Other Electronic Industries (SIC 335), disaggregated to the four-digit level, are available for 1982 through 1984. Table 4.7 provides summary statistics for the Telecommunications Equipment Industry (SIC 3351). The table indicates that 49 establishments manufactured telecommunication equipment in 1984. These establishments employed 21,639 workers that year, or an average of 442 workers per establishment. They paid salaries and wages of \$638 million. Value-added by telecommunication equipment manufacturers equalled \$1.2 billion in 1984 so that value-added per worker was \$57,400.

Data for Electronic Parts and Components, and Other Communication and Electronic Equipment Industries (SIC 3352 and 3359) appear in Tables 4.8 and 4.9 respectively. It is clear that most of the activity of the Communications and Other Electronic Equipment Industries (SIC 335) takes place in Ontario. In 1984, 276 (or 58 per cent) of the establishments in this industry group were located in Ontario. These establishments were responsible for 57 per cent of the industries' shipments and 57 per cent of their value-added. They hired 30,797 employees (59 per cent of the total). Data on the remaining provinces are incomplete but it appears that Quebec is next most important and that the other provinces are much smaller contributors. This regional pattern of production is not unexpected. Ontario and Quebec are Canada's largest population centres and, hence, represent the most concentrated market areas. They are also in an advantageous location close to highly concentrated population centres in northeastern United States. Moreover, the amenities available in the large urban areas of these provinces provide a living

Table 4.5
Summary Statistics for Communications and Other Electronic
Equipment Industries (SIC 335)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1976	261	38 467	498 665	1 383 162	953 838
1977	250	36 676	516 261	1 441 330	1 013 449
1978	331	37 895	565 776	1 532 406	1 100 164
1979	384	39 326	685 716	1 813 826	1 368 835
1980	411	43 343	797 035	2 328 935	1 629 463
1981	427	46 330	944 401	2 786 459	1 935 025
1982	443	45 629	1 043 935	3 055 291	2 169 711
1983	424	45 164	1 127 730	3 125 415	2 117 977
1984	476	51 769	1 348 124	3 820 551	2 666 339
CGR(%)	7.8	3.8	13.2	13.5	13.7

Note: CGR means Compound Growth Rate

Source: Statistics Canada 43-206.

Table 4.6
Performance Statistics for Communications and Other
Electronic Equipment Industries (SIC 335)

	Employees per Estab- lishment	Shipments per Estab- lishment	Value Added per Employee	Average Wage	Pre-tax Profit on Total Income ^a
	number	\$thousand	\$thousand	\$thousand	per cent
1976	147	5 299	25	13	4.7
1977	147	5 765	28	14	2.0
1978	115	4 630	29	15	2.9
1979	102	4 724	35	17	6.2
1980	106	5 667	38	18	6.1
1981	109	6 526	42	20	4.5
1982	103	6 897	48	23	4.3
1983	107	7 371	47	25	5.4
1984	109	8 026	52	26	6.1

^a Excludes investment income

Source: Table 4.5 and Statistics Canada 61-207.

Table 4.7
Summary Statistics for Telecommunication Equipment
Industry (SIC 3351)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1982					
Ontario	24	12 044	312 362	957 256	743 475
Quebec	12	X	X	X	X
Other	X	X	X	X	X
Canada	X	20 522	521 978	1 644 619	1 188 344
1983					
Ontario	21	10 934	318 462	842 454	550 196
Quebec	11	X	X	X	X
Other	25	X	X	X	X
Canada	57	18 835	532 409	1 540 919	995 994
1984					
Ontario	19	12 351	364 086	1 033 856	721 901
Quebec	10	X	X	X	X
Other	20	X	X	X	X
Canada	49	21 639	637 817	1 817 205	1 241 676

X Confidential to meet secrecy requirements of the Statistics Act.

Source: Statistics Canada 43-206.

Table 4.8
Summary Statistics for Electronic Parts and Components
Industry (SIC 3352)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1982					
Ontario	134	6 326	104 582	300 713	172 311
Quebec	36	X	X	X	X
Other	26	X	X	X	X
Canada	196	8 229	137 385	391 554	220 783
1983					
Ontario	125	6 315	114 106	333 901	189 132
Quebec	28	1 639	34 084	93 597	62 187
Other	22	370	5 997	19 843	11 295
Canada	175	8 324	154 187	447 341	262 614
1984					
Ontario	142	6 370	113 845	343 370	205 644
Quebec	37	X	X	X	X
Other	29	X	X	X	X
Canada	208	9 873	198 834	610 429	371 957

X Confidential to meet secrecy requirements of the Statistics Act.

Source: Statistics Canada 43-206.

Table 4.9
Summary Statistics for Other Communication and Electronic
Equipment Industries (SIC 3359)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1982					
Ontario	97	9 632	212 455	554 744	385 138
Quebec	43	6 226	151 184	438 133	364 667
Other	38	1 181	24 174	34 902	15 148
Canada	178	17 039	387 813	1 027 779	765 953
1983					
Ontario	99	10 444	251 739	636 341	499 069
Quebec	50	6 462	166 050	471 297	345 435
Other	43	1 099	23 345	30 297	14 865
Canada	192	18 005	441 134	1 137 955	859 369
1984					
Ontario	115	12 076	293 415	784 510	593 180
Quebec	53	6 684	186 334	565 560	435 491
Other	51	1 497	31 724	42 847	24 035
Canada	219	20 257	511 473	1 392 917	1 052 706

Source: Statistics Canada 43-206.

environment that is attractive to many of the professionals required for these industries. (Industry officials indicate that a large proportion of establishments are located near Toronto and Montreal for this reason).

Tables 4.10 and 4.11 report summary and performance statistics for the Office, Store and Business Machine Industries (SIC 336). The number of establishments grew rapidly between 1976 and 1984, increasing at 14.1 per cent per year, from 47 to 135. Employment grew rapidly as well, surpassing overall Canadian employment growth by about 5 per cent. Wages and salaries grew about 7 per cent faster than the Canadian average, and real wage in 1984 was \$27,200 (in 1985 dollars)—slightly higher than that for Communications and Other Electronic Industries and about \$5,000 above the average for the economy. Shipments of goods of own manufacture rose at the annual rate of 19.1 per cent between 1975 and 1984, reaching about \$1.7 billion by the period's end. Shipments per establishment were \$12.3 million in 1984, about 50 per cent higher than the average for Communications and Other Electronic Industries. Nominal value-added in the industries was just over \$1 billion in 1984 and value added per employee rose by 10.6 per cent annually beginning 1976. Limited price data show that output price for the industries held constant since 1981, suggesting that real value added per worker has risen quite rapidly. There is no readily available information on profit levels in Office Store and Business Machines Industries.

In Table 4.12 data on the Electronic Computing and Peripheral Equipment Industry (SIC 3361) show that 91 establishments (or 67 per cent of the SIC 336 industries' total) were designated to this industry in 1984. These establishments employed 10,953 workers that year, or 64 per cent of the industries' total. Computer equipment manufacturers shipped about \$1.3 billion in goods of own manufacture. This was \$14.2 million per establishment, an average slightly above the average for the industry as a whole. Value added in computer equipment manufacturing was \$747 million in 1984, or \$68,200 per worker. This was about \$10,000 per worker above the industries' average. Again, most productive activity occurs in Ontario, with Quebec second and the remaining provinces providing substantially less.

Table 4.13 contains combined information about the Electronic Office, Store and Business Machine Industry (SIC 3362) and Other Office, Store and Business Machine Industries (SIC 3369). Statistics Canada does not break out these industries separately. The table shows that in 1984, 44 establishments hired 6,202 employees and paid \$169 million in wages and salaries. These establishments accounted for \$255 million in value-added and shipped \$372 million of goods and

Table 4.10
Summary Statistics for Office, Store and Business Machine Industries (SIC 336)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1976	47	9 758	129 870	412 017	253 329
1977	41	8 635	124 321	417 443	231 420
1978	55	9 629	144 872	546 847	267 490
1979	64	11 791	194 325	725 454	409 182
1980	75	13 540	250 662	889 047	521 190
1981	71	16 161	333 800	1 146 511	671 805
1982	92	16 930	392 325	1 179 602	776 839
1983	106	15 883	414 864	1 282 841	788 729
1984	135	17 155	451 724	1 662 497	1 001 847
CGR(5)	14.1	7.3	16.9	19.1	18.8

Source: Statistics Canada 42-216.

Table 4.11
Performance Statistics for Office, Store and Business Machine Industries (SIC 336)

	Employees per Establishment	Shipments per Establishment	Value Added per Employee	Real Wage per Employee ^a
	number		\$thousand	
1976	208	8 766	26.0	25.6
1977	211	10 182	26.8	25.8
1978	175	9 943	27.8	25.2
1979	184	11 335	34.7	25.1
1980	181	11 854	38.5	25.3
1981	228	16 148	41.6	25.3
1982	184	12 822	45.9	25.7
1983	150	12 102	49.7	28.0
1984	127	12 315	58.4	27.2

a Deflated by GNP deflator, 1985 = 100

Source: Table 4.10.

Table 4.12
Summary Statistics for Electronic Computing and Peripheral
Equipment Industry (SIC 3361)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1982					
Ontario	n.a.	n.a.	n.a.	n.a.	n.a.
Quebec	n.a.	n.a.	n.a.	n.a.	n.a.
Other	n.a.	n.a.	n.a.	n.a.	n.a.
Canada	47	7 841	180 826	680 698	383 070
1983					
Ontario	40	5 545	144 588	667 892	378 219
Quebec	9	683	15 146	30 157	17 844
Other	10	1 812	40 241	102 830	82 580
Canada	59	8 040	199 975	800 879	478 683
1984					
Ontario	59	7 426	196 238	1 071 723	581 833
Quebec	15	1 320	31 813	86 561	47 644
Other	17	2 207	54 425	132 149	117 621
Canada	91	10 953	282 476	1 290 433	747 098

Source: Statistics Canada 42-216.

Table 4.13
Summary Statistics for Electronic Office, Store and Business
Machine Industry (SIC 3362) and Other Office, Store and
Business Machine Industries (SIC 3369)

	Establish- ments	Employees	Wages and Salaries	Shipments of Goods of Own Manufacture	Value Added
	number			\$thousand	
1982					
Ontario	n.a.	n.a.	n.a.	n.a.	n.a.
Quebec	n.a.	n.a.	n.a.	n.a.	n.a.
Other	n.a.	n.a.	n.a.	n.a.	n.a.
Canada	45	9 015	210 470	497 309	390 999
1983					
Ontario	29	3 853	108 251	241 535	190 363
Quebec	13	3 193	84 510	234 975	115 859
Other	5	797	22 138	5 452	3 824
Canada	47	7 843	214 899	481 962	310 046
1984					
Ontario	27	3 548	99 794	251 296	202 320
Quebec	10	1 934	49 191	113 042	47 539
Other	7	720	20 263	7 726	4 890
Canada	44	6 202	169 248	372 064	254 749

Source: Statistics Canada 42-216.

own manufacture. It is clear, again, that most of these industries' production occurs in Ontario.

Tables 4.14 and 4.15 deal with the Telecommunication Carriers Industry (SIC 482). This SIC category traditionally has been made up of Telephone Systems (1970 SIC 544) and Telegraph and Cable Systems (1970 SIC 545). The latter included purely telecommunication carriers. However, the distinction between telephone systems and other forms of telecommunication has become less clear and the 1980 SIC amalgamated the separate categories into one. This is the largest category in the sector, and telephone systems comprise its largest portion by far. In 1984, the telecommunication carriers industry employed 102,503 workers, of which 96,602 (or 94 per cent) were employed by telephone systems. It is interesting to note that industry employment peaked in 1982 at 111,088 workers. The number of industry establishments declined at the compound annual rate of 20 per cent between 1976 and 1985, mainly because the

Table 4.14
Summary Statistics for Telecommunication Carriers Industry
(SIC 482)^a

	Establish- ments ^b	Employees ^c	Wages and Salaries ^c	Operating Revenue ^c	Operating Expense ^c
	number			\$thousand	
1976	859	90 477	1 375 850	3 763 716	3 326 468
1977	342	94 409	1 561 709	4 264 397	3 803 638
1978	269	100 023	1 764 014	4 931 714	4 375 567
1979	233	103 786	2 020 660	5 751 601	5 069 181
1980	191	106 114	2 321 337	6 617 621	5 938 115
1981	158	108 743	2 723 591	7 872 691	7 086 613
1982	125	111 088	3 060 308	8 859 924	8 075 221
1983	128	106 522	3 189 875	9 540 258	8 541 112
1984	128	102 503	3 353 063	10 322 659	9 210 084
1985	115	99 816	3 414 207	10 626 590	9 405 263
CGR(%)	-20.0	1.1	10.6	12.2	12.2

a Telephone Systems (1970 SIC 544) plus Telegraph and Cable Systems (1970 SIC 545).

b Estimated from information provided by Statistics Canada.

c Estimated for 1970 SIC 545 by multiplying values by 1.126 for the years 1983 to 1985 to account for unsurveyed establishments.

Source: Statistics Canada 56-001, 56-201 and 56-203.

number of telephone systems fell from 850 to 106 over the period. Meanwhile, the number of employees per establishment rose dramatically from 105 to 868. In 1984, telecommunication carriers paid wages and salaries of \$3.4 billion and telephone systems paid \$3.162 billion, or 94 per cent of this total. Real wage per employee is highest in the sector, equalling \$34,200 in 1985. Operating revenue is also the sector's largest; in 1984 operating revenue exceeded \$10.3 billion, telephone systems accounting for \$9.696 billion. Of course operating revenue per establishment rose between 1976 and 1985, and operating revenue per employee increased at 11 per cent per year to \$106,500 in 1985. Operating profit as a percentage of operating revenue averaged 10.8 per cent over the period.

While the Telecommunication Carriers Industry is the largest in the sector, Computers and Related Services (SIC 772) is growing the fastest. Table 4.16 indicates that the number of establishments increased at almost 20 per cent per year between 1976 and 1984. Operating revenue rose by 14 per cent annually to almost \$3 billion in 1984. The value-added resellers are an important recent phenomenon contributing to this growth. Information about their activity is included with SIC 772 and Statistics Canada will provide specific detail about this group beginning with their 1986 data. In 1984, 2,209 establishments employed 32,160 workers (a 6.7 per cent annual increase over 1976) and paid \$940 million in wages (a growth rate of 14.2 per cent). The number of workers per establishment fell over the period to 15 in 1984, and real wage was constant at just over \$30,500 (in 1985 dollars). Operating revenue per establishment fell over the period to \$1.35 million in 1984, while operating revenue per employee rose by 6.8 per cent per year to \$92,700 in 1984. Limited data on SIC 7772 show very high operating profit rates. More extensive data on the computer software and services industry (Table 4.17) indicate that operating profit rates averaged 12.7 per cent before the 1982 recession and 5.8 per cent afterward. It is notable that this accounts for most of the growth in computer and related services.

The information technology sector is clearly making an important contribution to Canadian economic activity. Research and development is a key determinant of the sector's viability and Table 4.18 presents some information on R&D expenditure. Between 1977 and 1985 Computer Services increased R&D spending by 42.3 per cent annually. This greatly exceeds the average for all Canadian industries of 17 per cent. Manufacturers of Business Machines and Communications Equipment, at 34.1 per cent and 22.5 per cent respectively, also surpassed the national average. In fact, together with Computer Services, these industries accounted for 35 per cent of all R&D spending in Canada during 1984. Moreover, of the \$1.001 billion expenditure by these R&D performers that year, \$718 million

Table 4.15
Performance Statistics for Telecommunication Carriers
Industry (SIC 482)

	Employees per Establish- ment	Operating Revenue per employee	Real Wage per Employee ^a	Operating Profit on Operating Revenue
	number	\$thousand		percent
1976	105	41.6	29.2	11.6
1977	276	45.2	29.6	10.8
1978	372	49.3	29.6	11.3
1979	445	55.4	29.6	11.9
1980	556	62.4	29.9	10.3
1981	688	72.4	30.7	10.0
1982	889	79.8	30.6	8.9
1983	832	89.6	32.1	10.5
1984	801	100.7	33.8	10.8
1985	868	106.5	34.2	11.5

a Deflated by GNP deflator, 1985 = 100.

Source: Table 4.14

Table 4.16
Summary Statistics for Computer and Related Services
(SIC 772)

	Establish ments	Employees	Wages and Salaries	Operating Revenue
	number		\$thousand	
1976	516	19 172	324 194	1 048 196
1977	622	20 172	337 627 ^a	1 213 135
1978	730	22 003	402 945 ^a	1 411 602
1979	719	23 838	483 917 ^a	1 567 949
1980	1 068	27 303	591 927 ^a	1 930 470
1981	1 420	30 550	787 064	2 513 492
1982	1 808	32 202	907 289 ^a	3 193 519
1983	1 918	28 249	815 354	2 492 695
1984	2 209	32 160	939 932	2 982 164
CGR(5)	19.9	6.7	14.2	14.0

a Excludes benefits in SIC 7722.

Source: Statistics Canada 63-222.

Table 4.17
Performance Statistics for Computer and Related Services
(SIC 772)

	Employees per Estab- lishment	Operating Revenue per Estab- lishment	Operating Revenue per Employee	Real Wage per Employee ^a	Operating Profit on Operating Revenue
	number		\$thousand		per cent
1976	37	2 031	54.7	32.5	27.6 ^c
1977	32	1 950	60.1	29.9 ^b	28.4 ^c
1978	30	1 934	64.2	30.7 ^b	14.1 ^d
1979	33	2 181	65.8	30.9 ^b	12.1 ^d
1980	26	1 808	70.7	29.6 ^b	11.1 ^d
1981	22	1 770	82.3	31.5	13.5 ^d
1982	18	1 766	99.2	31.3 ^b	8.6 ^d
1983	15	1 300	88.2	30.9	2.8 ^d
1984	15	1 350	92.7	30.2	6.0 ^d

a Deflated by GNP deflator, 1985 = 100

b Excludes benefits for SIC 7772

c SIC 7722 only

d SIC 7721 only

Source: Table 4.16.

Table 4.18
Total R&D Expenditure by Industry

	Communi- cation Equipment (335)	Business Machines (336)	Transport- ation and Other Utilities ^a	Computer Services (772)	All Canadian Industries
			\$million		
1977	155	16	49	4	857
1978	176	23	41	6	1 006
1979	219	37	41	8	1 226
1980	264	59	48	16	1 570
1981	384	84	72	25	2 125
1982	503	124	92	36	2 493
1983	631	140	96	56	2 584
1984	750	166	100	85	2 859
1985 ^b	901	199	105	90	3 322
1986 ^b	961	224	111	96	3 528
CGR(%)	22.5	34.1	9.5	42.3	17.0

a Includes SIC 482

b Preliminary

Source: Statistics Canada 88-202.

(or 72 per cent) was spent by Canadian-controlled firms. In all Canadian industries, the proportion spent by Canadian-controlled firms was somewhat lower at 64 per cent. Transportation and Other Utilities increased R&D spending at below the national rate; telecommunication carriers are included on this group but data for these carriers are not separately available.

Table 4.19, on external trade in Information Technology Sector products concludes the statistical overview. The problems related to these types of estimates are discussed in Chapter VI. These data show that Canada has run a large and growing trade deficit in computers and related equipment. While trade deficits are often adversely interpreted by the public, it is also true that computers and related equipment play an important role in productivity improvement. Thus the adoption of computer technologies, wherever their source, must be considered beneficial to the Canadian economy. Moreover, the limited data available indicate that Canadian computer production is expanding rapidly. Trade in Telecommunications Equipment initially was in a deficit position but moved to a surplus that totalled \$441 million in 1985. As information technology services matured, they moved from initial deficits to surpluses as well. Communications Services generated a \$42 million surplus in 1984 while net Computer Services receipts equalled \$53 million. These three components of the sector illustrate that, given the opportunity, some segments of Canada's evolving IT sector could compete in world markets.

A few additional issues should be emphasized. In particular, our in-depth analysis of the trade and production data of the computer industry has revealed some patterns which we believe are of relevance to the Canadian information technology sector in general and perhaps even to the Canadian high-tech sector as a whole.

For instance, the data on trade in the Office Machinery category indicates that more than 90 per cent of the trade consists of computers and computer parts, and that most of the trade is with the United States. There have been substantial increases in both imports and exports of office machinery in the past few years. In fact, these increases have been larger than for most other high-technology product groups. The data also reveal that intra-industry trade is an important feature in this case, with 87 per cent of domestic shipments exported and 95 per cent of apparent Canadian consumption consisting of imports in 1981.

The input-output data provide more detail to this effect. Almost all of the Canadian production of office machinery is destined for export to the United States. Looking at office machinery manufacturing establishments in 1981, we see that these are responsible for most of the \$859 million worth of exports of office machinery, and that

Table 4.19
External Trade in Products Related to Information Technology^{a,b}

	Telecommunications Equipment			Computer and Related Equipment			Communications Services			Computer Services		
	M	X	B	M	X	B	M	X	B	M	X	B
	\$million											
1977	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	79	86	7	n.a.	n.a.	n.a.
1978	621	416	-205	937	502	-435	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1979	762	609	-153	1 194	734	-460	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1980	840	836	-4	1 743	853	-890	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1981	1 034	1 054	20	2 410	1 034	-1 376	210	154	-56	73	52	-21
1982	955	1 170	215	2 715	1 109	-1 606	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1983	1 087	1 309	222	2 957	1 305	-1 652	194	237	43	68	80	12
1984	1 381	1 867	486	4 223	1 765	-2 458	262	304	42	57	110	53
1985	1 488	1 929	441	4 003	1 877	-2 126	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

n.a. not available

a Product categories do not necessarily correspond to the SIC codes used throughout this study.

b M,X,B, signify imports, exports and balance, respectively.

Source: Statistics Canada (1987) and Statistics Canada 67-510.

approximately \$461 million worth of imports of office machinery accrues directly to them. The data show that the other major end users of office machinery imports are the commercial and financial services industries and the electric power industries.

These patterns reflect the workings of a sector that operates on an international basis. One of the main characteristics of the computer industry worldwide is its high degree of concentration. Data for 1982 indicate that the United States accounts for 58 per cent of worldwide computer revenues, with IBM controlling 42 per cent, and the top eight U.S. firms controlling 74 per cent of worldwide revenues. Of the world's top 10 computer firms in 1981, eight are multinational enterprises with parent firms in the United States. The two others are in Japan (Paul 1984). It is interesting to note that these same U.S. firms are also found in the list of top computer manufacturers in Canada in relatively the same order of importance, with approximately the same magnitude of revenue differences. Also, depending on the ranking criteria used (total revenues or electronic data processing revenues), only one or at most two Canadian-owned firms are to be found among Canadian industry leaders. Again, IBM is the uncontested leader accounting for approximately 59 per cent of electronic data processing (EDP) revenues of the 10 major EDP hardware suppliers in 1985. To put this situation in perspective, one need only consider the fact that Canadian-controlled firms accounted for only 26 per cent of the shipments and 23 per cent of the total value added by office and store machinery manufacturers in 1981 (Statistics Canada 31-203).

The patterns revealed by the Canadian data are in line with these observations. The intra-industry trade, indicated in the trade statistics, is a reflection that the major manufacturers of office machines and equipment are establishments of multinationals who operate under some kind of product rationalization approach (or are undergoing changes in that direction), resulting in international specialization with Canadian manufacturing facilities producing for a worldwide market. The bulk of production and trade is accounted for by Canadian subsidiaries of multinational firms that have obtained "a mission" or "contract" as the supplier of particular products to affiliates mostly in the United States. The product imports which are not to be used directly in production or assembly are routed through from the original equipment manufacturer or some related sales and marketing operations abroad and/or in Canada, or through affiliated and nonaffiliated wholesale and retail establishments. Very little is produced in Canada specifically for the Canadian market.

Another important point to make is that the majority of the imports of office machines and equipment represent capital goods

purchases used to upgrade the production processes in a variety of Canadian industries, particularly service industries.

Conclusion

The importance of information technology for productivity improvements throughout the entire economy cannot be overemphasized. Computers, telecommunications, and robotics are essential elements of technological progress in most economic activities. In its discussion of policy issues related to information technology, the OECD (1987) points out that (1) no country can afford to ignore the potential gains from the use of information technology-based processes and the incorporation of information technologies into consumer products, (2) the skill intensity, the operation costs and the economies of scale associated with the manufacture of IT-based capital goods (computers, industrial robots and NC machine tools) suggests that only certain countries will be able to operate effectively in this area on a large scale, and (3) that although the design and manufacture of electronic components or chips can be undertaken separately, the skill intensity of the former and the labour intensity of the latter suggest that these activities will not be appropriate for all economies.

It seems reasonable, therefore, to expect that a small country like Canada will be the innovator and manufacturer of only a small portion of the world's latest products and production processes. In order to introduce the latest in modern technology, Canadian firms will have to import machinery and equipment in which that technology is embodied. Hence, a negative balance of trade in these products may not reflect a failure on Canada's part. Rather, it may reflect the creative application of the world's latest technology in the production facilities of other economic sectors. Canada's negative balance of trade in information technology may best be seen as the natural result of applying new technology throughout the Canadian economy.

We would also suggest that to be able to assess the role of the information technology in Canada's economy it is necessary to understand the evolving nature of IT-based technological change. This process is closely related to the phenomenon of increased global competition and the growing importance of services even within the manufacturing sector. More important, it may prove instrumental in causing a shift from "scale" to "scope" in economies of production. This indicates that rationalization and specialization may not, after all, be the only answers to Canada's lack of competitiveness in manufacturing. The possibility of such a shift signals a change in future labour requirements with emphasis on skill and adaptability.

Finally, evidence suggests that the patterns of trade, production and technology transfers in the IT sector (and probably in many other high-tech areas as well) are to a great extent determined by the modes of operation of multinationals. However, although it is relatively easy to observe the trade balance directly associated with the production activities of these large manufacturers, it is more difficult to take into account adequately the value of the technological transfers that take place through the various channels available in intra-firm transactions. It is quite clear, from the data available, that the way in which a relatively small number of large multinationals allocate resources, has a significant impact on the industrial and market structures of the sectors in question. Recognizing the importance of these operations will facilitate setting policy objectives. These and other questions concerning the roles of the multinational enterprise in the high-tech area are addressed in the next chapter.

Chapter V

The Multinational Enterprise

Introduction

The data on foreign ownership of manufacturing industries indicate that since 1972 there has been a steady decline in the proportion of Canadian manufacturing assets that are foreign-controlled. However, in every Canadian high technology industry, with the exception of communications, the proportion of foreign-controlled manufacturing assets remains well above 50 per cent. The prevalence of large, mostly U.S.-based multinational enterprises (MNEs) is a key determinant of the patterns of trade and production in Canada's high-tech sector.

There is considerable disagreement on the welfare consequences of extensive foreign control for the host country. Nationalists have argued that industries dominated by multinationals are characterized by truncated branch plants that use inefficient methods of production and are often limited to an assembly function. Production in these subsidiaries is oriented to the domestic market with little export capability, while much of the product line is imported as finished products. It is also believed that most of the key management functions, such as investment decisions, R&D, market research, and systems development, remain in the parent country with the foreign subsidiaries' management role limited to sales and immediate supervision. On the other hand, the multinationalist position has been that subsidiaries improve the performance of industries in the host country through technology transfers that would otherwise occur at a much slower pace and at a higher cost. They also generate substantial employment and tax revenues, and provide a larger

market for host country materials and services. While nationalists often point to foreign control as a significant factor explaining lower productivity in Canada, the multinationalists attribute the problem to the size of the market and trade restrictions. Research conducted for the Royal Commission on the Economic Union and Development Prospects for Canada lends considerable support to the latter position.

In this chapter we first look at the determinants of MNE production and trade and investment in the high-tech sector where such firms appear to have gained a competitive advantage. We then describe the role of MNEs as allocators of capital, labour, and technology on a worldwide basis. Indications are that this role is significant, particularly for MNEs operating in high-tech industries. The issues of transfer pricing and world product mandating are also assessed as they relate to the impact of foreign direct investment.

The Significance of Foreign Ownership

Foreign-owned subsidiaries (over 90 per cent of which are U.S. based) accounted for about 45 per cent of total assets and 50 per cent of total sales in Canadian manufacturing in 1982, making Canada one of the world's most important host countries. Table 5.1 reports 1981 data on foreign control for selected manufacturing industries conventionally classified in the high-tech sector. In each of these industries, with the notable exception of communications, the ratio of foreign control is substantially above average and in most cases well over 50 per cent. In fact, as Niosi (1985) pointed out, it appears that the most sophisticated Canadian industries are also the ones with the highest degree of foreign control.

This is not a uniquely Canadian phenomenon, however. Observations by Stopford and Dunning (1983) indicate that certain technologically intensive sectors are dominated by MNE affiliates in most countries. The United States is the home country of 21 per cent of all parent companies, with U.S. foreign direct investment (FDI) giving rise to 44 per cent of the total world stock of international direct investment in 1980. In 1975, 67 per cent of U.S. outward direct investment was in technology-intensive sectors. In 1981, 72 per cent of U.S. MNEs' foreign production, except for petroleum, was in industries that spent 2 per cent or more of sales revenues on research and development (R&D). According to Stopford and Dunning (1983), U.S. MNEs appear to have invested largely in sectors where the U.S. economy has gained a competitive advantage. This has had significant implications for the Canadian economy.

Table 5.1
Domestic and Foreign Control of Selected
High Technology Industries, Canada, 1981
(percentages)

Industry	Shipments			Total Value Added			Total Employees		
	Canada	U.S.	OF ¹	Canada	U.S.	OF	Canada	U.S.	OF
Office and Store Machinery ²	25.8	-	-	22.9	-	-	29.8	-	-
Aircraft and Aircraft Parts	42.0	48.8	9.1	42.3	47.0	10.5	47.7	43.4	8.7
Communications Equipment	64.6	28.8	6.5	65.7	27.1	7.0	58.8	32.4	8.6
Electrical Industrial Equipment	16.5	64.3	19.1	14.1	68.2	17.6	17.3	64.3	18.2
Plastics and Synthetic Resins	18.4	71.2	10.3	18.9	68.9	12.1	21.7	70.7	7.5
Pharmaceuticals and Medicines	15.8	64.6	19.4	12.5	66.9	20.5	17.8	62.2	19.9
Industrial Chemicals Inorganic	32.9	51.6	15.4	41.0	44.5	14.4	27.5	46.9	25.5
Industrial Chemicals Organic	31.8	58.4	9.7	29.7	61.6	8.5	28.5	64.2	7.2
Instruments and Related Products	24.8	72.0	3.0	23.7	73.6	2.5	27.5	68.8	4.1
Manufacturing	54.0	35.5	10.4	55.8	34.1	9.9	62.8	28.7	8.4

1. Other foreign.

2. The data detail indicating U.S. and other foreign control is not available for 1981 for this industry. However, the 1978 estimates reveal that U.S. controlled enterprises accounted for virtually all non-Canadian controlled shipments, value added and employment in office machinery.

Source: Statistics Canada. *Domestic and Foreign Control of Manufacturing, Mining and Logging Establishments in Canada 1981*, Ottawa, Cat. 31-401, July 1985.

Canadian businessmen have most effectively resisted foreign control in sectors with little technological complexity – finance, commerce, services, construction and agriculture. These data are the confirmation of the central role of the technological factor in foreign control in Canada. The entry of Canadian firms into such [high technology] industries appears to have been prevented by technological barriers (Niosi 1985, p. 38).

The computer industry is an example of this. In 1981, the United States accounted for 58 per cent of world computer production. IBM controlled 42 per cent of U.S. worldwide revenues while the top eight firms accounted for 74 per cent of these revenues. These same companies are also found in the list of top 10 companies in the Canadian industry. Table 5.2 indicates the importance of U.S. multinationals in the Canadian information processing industry. Although Northern Telecom (NT) is not included here, it is actually one of the few Canadian multinationals in the high technology sector and it specializes mainly in telecommunications equipment. However, NT is estimated (based on 1980 data) to derive approximately 28 per cent of its revenues from electronic data processing (EDP) sources. IBM remains the uncontested leader in the Canadian computer industry and the world for that matter. In 1985, it accounted for almost 60 per cent of the EDP revenues of the top 10 EDP hardware suppliers in Canada.

The extensive foreign ownership of Canada's manufacturing sector results in a significant portion of Canadian trade occurring between foreign-owned Canadian subsidiaries and their affiliates abroad. Data for 1978 indicate, for instance, that imports of foreign owned Canadian companies (with assets of more than \$5 million) from related companies accounted for 30 per cent of total Canadian imports for that year. The corresponding export ratio was 28 per cent. In 1981, an average of about 76 per cent of exports and 73 per cent of imports of major foreign-owned Canadian corporations consisted of interaffiliate transactions. These figures are consistent with Stopford and Dunning's (1983) observation that technologically advanced industries tend to engage in more intra-firm trade than other industries.

An analysis of 1978 data on Canadian imports by domestic- and foreign-controlled enterprises reveals the significance of these aspects of foreign ownership. Foreign-controlled importers were found to account for 72 per cent of the identified imports. The U.S.-controlled importing firms accounted for 80 per cent of foreign-controlled imports, three-quarters of which were end products. The foreign manufacturing companies' import propensity (ratio of imports to

Table 5.2
The Top 30 Companies in the Canadian Computer Industry
(millions of dollars)

Company Name	Ownership	Total Revenues 1986	EDP Revenues 1986
IBM Canada Ltd.	U.S.	2,924.0 ¹	2,784.0
Digital Equipment of Canada Ltd.	U.S.	631.8	631.8
Computer Innovations Distribution Inc.	Can.	255.6	255.6
Burroughs Memorex Inc.	U.S.	n/a	248.6
Control Data Canada Limited	U.S.	228.0	228.0
NCR Canada Ltd.	U.S.	210.0 ¹	195.3
Crowntek Inc.	Can.	183.1	183.1
Hewlett-Packard (Canada) Ltd.	U.S.	284.2 ¹	179.4
Canada Systems Group (CSG)	Can.	152.4	152.4
AES Data Inc.	Can.	133.0	133.0
Honeywell Bull Limited	U.S.	121.0	121.0
Amdahl Canada Limited	U.S.	120.5	120.5
Apple Canada Inc.	U.S.	118.8	118.8
Philips Information Systems Ltd.	NL.	125.4	118.8
Wang Canada Limited	U.S.	118.3	118.3
Gandalf Technologies Inc.	Can.	107.8	107.8
Olivetti Canada Limited	Lux.	128.4	106.6
SHL Systemhouse Inc.	Can.	104.9	102.8
Xerox Canada Inc.	U.S.	864.9 ¹	98.0
Sperry Inc.	U.S.	153.1	96.5
Radio Shack Canada	U.S.	302.5	90.8
CMI Corporation, Canada	U.S.	85.0	85.0
Comdisco Canada, Ltd.	U.S.	84.6	84.6
Motorola Information Systems	U.S.	84.3	84.3
DMR Group Inc.	Can.	80.0	80.0
National Semiconductor Canada Ltd.	U.S.	78.0 ¹	78.0
Data General (Canada) Inc.	U.S.	71.6 ¹	71.6
Commodore Business Machines Ltd.	Bah.	70.0 ¹	70.0
Cognos Inc.	Can.	68.4	68.4
Tandem Computers Canada Limited	U.S.	66.0	66.0

1. Estimated

Source: Evans Research Corporation. *Corporate Strategies for the Computer Industry*, 1987 edition.

sales) was nearly four times greater than that of domestic firms. The data also indicate that foreign-controlled subsidiaries sourced their imports mainly from the home countries. The rate was 87 per cent for U.S.-controlled firms and 74 per cent for other foreign-controlled firms. It appears imports are very heavily concentrated, with the leading 50 importers responsible for almost 50 per cent of Canadian imports.

Table 5.3 reports import share data allocated on a producer industry basis for a number of high-tech industries. As the first three columns indicate, except for aircraft and aircraft parts manufacturers, U.S.-controlled importing firms accounted for most imports in these industries by a large margin. The remaining columns indicate the country of control of the top four and the top eight importers and the percentage of identified imports they account for. Again aircraft manufacturers are the exception to the rule. For other high-tech industries, the leading importers were mainly foreign-controlled firms and they accounted for a significant portion of imports.

Foreign-owned companies have generally been found to spend relatively less on R&D than Canadian-owned companies. On the other hand, as Table 5.1 indicates, foreign-controlled establishments accounted for 37 per cent of employment in manufacturing in 1981. Again the percentages are much higher in the high-tech industries, ranging from 52 to 82 per cent. The data also show that foreign subsidiaries' share in total industrial value added and wage bill exceeded the share in industrial employment. In general, the tendency has been for foreign-owned MNEs to establish only a small fraction of their total employment in Canada (for example, 3-4 per cent for computer manufacturers).

Multinational Enterprises and Foreign Direct Investment: Theoretical Considerations

According to traditional economic theory, capital movements among countries can be predicted by the differentials in the interest rates. Capital will move from countries where interest rates are low because capital is plentiful, to countries where rates are high and capital is scarce. However, as Hymer (1976) pointed out, the data on international capital movements do not support this theory. Movements have been concentrated mainly among countries where capital is relatively abundant. There is also considerable cross investment between countries. The fact is that almost all foreign direct investments (FDI) are carried out by firms based in the United States, Japan and a few European countries, and that their investments tend to be concentrated in a fairly small number of industrial sectors. This indicates that factors other than interest rate

Table 5.3
Canadian Imports by Domestic and Foreign Controlled Enterprises
in the High Technology Sector, Canada, 1978

Producer Industry	Country of Control of importing firms			Country of control and # of identified imports of Top 4 importing firms				Country of control and # of identified imports of Top 8 importing firms			
	% Canadian	% U.S.	% Other	# Canadian	# Foreign	# Imports	% of Imports	# Canadian	# Foreign	# Imports	% of Imports
Office and Store Machinery	8.6	82.4	9.0	0	4	44.2		0	8	53.6	
Aircraft and Aircraft parts	58.2	35.8	6.0	3	1	47.6		4	4	58.2	
Communications Equipment	39.4	48.7	11.8	2	2	20.0		2	6	30.4	
Electrical Industrial Equipment	17.8	48.5	33.7	0	4	17.8		0	8	26.5	
Pharmaceuticals and Medicines	13.6	50.3	36.2	0	4	17.9		0	8	30.3	
Industrial Chemicals (Inorganic)	28.4	50.3	21.3	1	3	20.4		3	5	30.6	
Industrial Chemicals (Organic)	14.1	62.7	23.3	1	3	19.0		1	7	31.1	
Misc. Chemical Industries	14.8	64.3	20.9	0	4	15.6		0	8	24.8	
Instruments & Related Products	29.6	57.8	12.7	0	4	17.0		1	7	24.4	

Source: Statistics Canada. *Canadian Imports by Domestic and Foreign Controlled Enterprises, 1978*, Cat. 67-509, 1981.

differentials are at play in the international operations of corporations that engage in foreign direct investment. According to Hymer, the firm's decision to undertake capital formation abroad will depend on whether it can earn more by producing and selling on location than by exporting, and whether it can earn more than local firms in doing so since it has to contend with higher costs (transportation, communications etc.).

This requires that the firm possess some countervailing advantage, transferable abroad, but not available to its local competitor. Further, the market for the sale of this advantage must be imperfect, for otherwise the firm would have no incentive to make a direct investment. Firms that possess such advantages tend to be large and prominent in their home market (McClain 1982, p. 292).

There are several types of market imperfections which create such countervailing advantages. These have been categorized by Kindleberger (1969) as follows:

- (1) imperfections in goods markets (product differentiation, marketing skills, administered prices);
- (2) factor markets (proprietary technology, managerial skills, discriminatory access to capital);
- (3) economies of scale internal and external to the firm and;
- (4) government-imposed market disruptions (limitations on output or entry).

Other contributions to the basic theory have pursued this line of argument. Vernon's (1966) international product cycle theory emphasizes that MNE production and trade are linked to a great extent to innovation and the international diffusion of new technology. This theory describes the links between trade and investment. In the first stage, a new product is developed and produced exclusively for the market where the innovation took place. If the product is successful, it is exported and foreign direct investment is required to establish distribution and service facilities abroad. In the second stage, the world market for the product has grown and the product becomes standardized, but the technology and scale of production continue to create barriers to entry. At this point, the firm may shift production to foreign subsidiaries to take advantage of cost differentials or, as a defensive measure, to retain its

share in a market where local competitors could gain an advantage from local production. In the third stage, when the product has become completely standardized, production will be carried out where it is most economical. In cases where foreign production is cost-effective, the home market might be served from abroad, although "the internationalization of production still implies the possibility of continuing exports of components and services or of complementary products by the parent firm" (McCullough and Owen 1982, p. 345). According to findings by Mansfield (1984), it appears that the product cycle is being compressed with time, with the export stage being truncated and sometimes eliminated. This observation is particularly relevant in the case of new products as opposed to new process technologies, which do not appear to be affected by this trend.

Wells (1980), on the other hand, tried to explain the characteristics of multinationals based in developing countries through his theory of an international "pecking order" where technology, once it has become more or less standardized, is picked up by European or Japanese firms that adapt it for a lower income market and export to semi-industrialized countries, which in turn will modify the product and sell it to less developed countries (LDCs). Magee's (1977) "appropriability theory" of direct investment focuses on the returns to specific information. According to this theory, MNEs specialize in the production of information that is most efficiently transmitted intra-firm. The incentive is for MNEs to produce sophisticated technologies because it is easier to appropriate the returns from these. The optimum size of a firm will be determined by the appropriability of the returns from, and the complementarities among, different types of information. Vernon's product cycle phase in which foreign direct investment first occurs is explained in terms of firms wanting to increase the "appropriability of proprietary technology" by reducing its rate of diffusion.

Buckley and Casson (1976) tried to integrate all of the relevant propositions from past work on MNEs into one encompassing theme. Their theory focuses on the imperfection and internalization of markets in intermediate goods such as technical and entrepreneurial expertise.

The activities of modern companies go well beyond the routine production of goods and services. Companies also produce a large number of semi-finished goods through research, marketing, organization, the training of groups of managers and workers, and the like. With increasing frequency, these intermediate products take the form of knowledge and skills which are incorporated in patents, personnel, or machines. When firms are faced with

markets in all these intermediate products that are highly imperfect and difficult to organize, they get around this obstacle by resorting to international expansion. In a world where companies seek to maximize profits and come up against highly imperfect markets (at one time primarily in raw materials and now mostly in technology), the internalization of these markets across national borders creates multinational enterprises (Niosi 1985, p. 17).

From his review of the theoretical literature, Niosi (1985) has derived a set of working hypotheses that provide a useful composite framework to study the role of multinationals. The main propositions are that:

- (1) most multinationals are found in the most concentrated industries and in those where R&D and technological barriers play the largest role;
- (2) multinationals are often the largest firms in each industry and they have a firm specific advantage, be it technological, organizational or other;
- (3) the products of these firms follow a cycle starting from innovation to complete standardization, at which stage the multinationals' advantage may or may not be subject to erosion depending on market restrictions put in place by the firm, the industrial policy in the host country and the level of complexity of the technology; and
- (4) as late developing countries become more industrialized, domestic subsidiaries of multinationals are established whose main asset might be the adaptation of technology originally developed in an advanced country for other markets.

The actual fields of activity of MNEs seem to conform rather well with this theory. For the most part these fit in the three broad categories identified by Stopford and Dunning (1983): (1) import-substituting activities, (2) primary product activities and, (3) rationalized product or process activities.

Import-substituting investments occur as predicted because of specific advantages inherent to the MNE as compared with local producers in the host country and because under certain conditions it can better exploit these advantages from a local production base.

These advantages are of three main kinds. First there are those, such as exclusive or privileged access to essential raw materials (for example, petrochemicals), patent protection (pharmaceuticals), economies of scale (motor vehicles), or possession of trademarks (cigarettes and toilet preparations) which reflect either the superior innovatory or entrepreneurial skills of MNEs or the nature of the economic and political environment of the home country. Second, there are those which arise because the branch plant is able to benefit from certain facilities – research and development, accounting services, for instance – at very small cost. Third, there are those that stem from MNEs which, because of their geographical diversification, have better access to information and knowledge about intermediate and final product markets than domestic firms (Stopford and Dunning 1983, p. 29).

The reasons for exploiting these firm specific advantages by producing from a foreign location vary. Lower transfer costs (in terms of transportation, tariffs or other import controls) and production costs (labour, energy, materials, taxes) are important factors. But other, more general types of incentives also come into play, such as the environment created by government policies towards FDI or better opportunities for marketing, servicing, or adapting products in and for the local market. It appears that during the post-war period, import-substituting investment decisions have been influenced mainly by the size and expected growth of local markets and the presence of tariffs or non-tariff barriers.

Although many of the factors characteristic of import-substituting investments also apply to MNE resource-based investments, the key variables in this case are naturally of a locational nature, that is, the geographical distribution of resources and the costs of exporting them.

Rationalized product or process investments have formed a trend since the 1970s, when some MNEs rationalized their foreign operations by adopting a centralized, integrated production and marketing strategy with underlying global objectives. Rationalized production by MNEs involves either the specialization of similar end products to be traded across national boundaries to take advantage of economies of scale for efficient world scale production, or vertical or process specialization to benefit from differential factor endowments in different parts of the world. The first type is an extension of the investments of MNEs into branch plants to reproduce the output of the parent and the presence of high levels of intra-industry trade between similarly industrialized countries. The second kind of

rationalization was "prompted mainly by growing differences in labour costs between the advanced industrial and the developing countries and [it] tends to be concentrated in labour intensive industries" (Stopford and Dunning 1983, p. 31).

End product specialization has benefited from increasingly freer access to large and standardized markets. In the case of vertical or process specialization, the lower labour costs and favourable tax and investment policies in less industrialized countries and the reduction of tariffs on intra-firm trade in the U.S. and Japan have been important factors. Whereas import-substituting investments are often linked to high transport costs, or tariffs which are obstacles to trade, rationalized product or process investments "flourish in conditions of free trade and low transport costs" (Stopford and Dunning 1983, p. 31).

By the end of 1980, import-substituting activities accounted for about 30 per cent of FDI stock (Stopford and Dunning 1983). The primary sector and rationalized investments each made up 20 per cent with the remaining 30 per cent allocated to services. The rate of growth of rationalized investments in manufacturing and in services has been the strongest since 1970 while the primary sector has experienced a steady reduction.

Multinational Enterprises and the Transfer of Technology

One of the recurring themes in the literature on multinationals is that of technology as a key element. In Hymer's work the issue of technological advantage is viewed as one of the main types of firm specific advantages which in the presence of imperfect markets allows firms to overcome the higher costs of producing in a foreign country. Innovation and the process of diffusion are also central to Vernon's product cycle theory while the "internalization" of markets in technology is the focus of Buckley and Casson's work (1976).

According to Caves (1985), the affinities between R&D and MNEs are quite extensive. In fact,

the extent of R&D spending is an excellent predictor of MNE activity in an industry. . . . Hence, in those industries where most R&D takes place, both the R&D and foreign investments are likely to be concentrated among the larger firms. Just as R&D promotes foreign investment, it is possible that foreign investment promotes R&D. The established MNE has in hand the knowledge needed to predict the payout to innovations in diverse national markets, not just the home market. If the MNE's

information network indeed yields an advantage for this purpose, it enjoys both a higher and more certain mean expected return from investments in innovation than a similarly placed single nation company (Caves 1985 p. 196).

It is therefore not a coincidence to find that: (1) the bulk of innovations still originate in the U.S., (2) the U.S. accounts for approximately half of the industrial R&D expenditures among OECD countries, (3) the U.S. is the home country of more MNEs than any other country, and (4) U.S. MNEs invest the most, in aggregate and in comparison to other foreign-based MNEs, in technology-intensive sectors.

The results of a study by Mansfield, Romeo and Wagner (1979) emphasize the relationships involved. First, it appears that the rate of return expected from R&D activities by a firm is directly related to the level of its overseas activities in terms of both exports and foreign subsidiaries. Second, the higher the level of expected return from R&D, the more likely the firm's orientation is towards basic research and long-run projects. Third, if the results of their R&D could not be exploited through their foreign subsidiaries, the firms estimated that their volume of R&D would drop by 12 to 18 per cent.

As Caves (1985) indicated, a central issue here is whether MNEs allocate R&D activity, as they allocate their production facilities, to maximize net revenue. This issue relates to the transferability of technical knowledge across nations, and the economies of scale associated with R&D activity.

Effective execution of R&D requires a continuous interchange of information with the manufacturing facilities of the company for research to be directed to significant economic problems and for the R&D solutions to prove operational. Because of the strategic role of R&D, a similarly close interface with top corporate management is also important. These requirements for close communication and interchange, along with any scale economies in the R&D function itself, seem to dominate the decision where to situate R&D activities. They call for centralization at company headquarters, but qualified by the centrifugal pull of manufacturing facilities dispersed to serve far-flung markets (Caves 1985, p. 198).

Research results seem to confirm these observations:

- The basic tendency is for research to be undertaken at corporate headquarters. Only about 10 per cent of U.S. MNE research is carried out abroad.
- Overseas R&D tends to focus on development rather than on research, on product and process improvements rather than on new products and processes.
- The degree of R&D decentralization is directly related to the relative importance of sales by foreign subsidiaries.
- Scale economies play a role either resulting in R&D being kept at headquarters or being decentralized in cases where foreign production is concentrated among only a few large subsidiaries.

As MNEs tend to dominate the development of technology in the United States, they are also perceived as the key vehicle through which U.S. technology is exported (Litvak, 1981). MNE-based technology transfers can be channelled through exports of goods, licensing agreements or joint ventures or through FDI. The multinational that sets up a subsidiary will transfer technology by training management and labour, by providing technology-specific information to engineers and technicians, by providing product-user services and by creating incentives for suppliers to upgrade their technology.

In general, firms with adequate capital resources will undertake FDI rather than licensing, for appropriability reasons. The estimated life of the innovation, the level of complexity of the technology and the concern to protect quality standards will all reinforce this preference. Licensing is more likely to be considered in cases where the foreign market is not sufficiently large, the firm lacks the necessary resources to undertake FDI, or there are expected returns from cross-licensing.

For U.S.-based MNEs especially, management has strongly preferred to capitalize on their possession of proprietary technology rather than to license it to potential competitors (Stopford and Dunning 1983, p. 40).

The importance of technology transfers through multinational activities should not be underestimated. For instance, in 1981 about 81 per cent of U.S. receipts of fees and royalties came from U.S. affiliates abroad. Of these, 82 per cent came from developed market economies. Canada's share was almost 17 per cent. In the same year, 81 per cent of Canada's total payments in royalties, fees, patents and trademarks originated from U.S.-controlled enterprises. In the case of

payments for management services and scientific research and development, the corresponding ratios were 87 per cent and 74 per cent respectively. In 1984, 36 per cent of Canada's industrial R&D was carried out by foreign subsidiaries.

Studies of international diffusion of new technologies reveal wide variations among countries in terms of time required to begin using a new process or producing a new product. A major factor seems to be the level of R&D expenditure in the relevant industries. "Countries that spend relatively large amounts... are likely to be close to the technological frontiers and able to imitate quickly whereas other countries may not be able to do so" (Mansfield 1985, p. 82). However, it is also the case that the transfer of technology will depend on whether such technology is suitable or profitable at a specific time. As technology becomes more standardized, transferring becomes less expensive, the scale more flexible and the risks less onerous. Therefore, depending on the industrial structure and market conditions, adoption lags may well vary for good reasons. Finally, the lag time may simply be the direct result of multinationals' operating strategies.

As reported by Mansfield, the mean age of technologies transferred to overseas subsidiaries in developed countries, in the 1960-1978 period, was about six years while transfers to developing countries occurred only after 10 years. On the other hand, the mean age of technologies transferred through channels other than subsidiaries was much higher, 13 years. According to Stopford and Dunning's (1983) observations, the technology transfer strategies of MNEs are quite different between developed and developing countries. In the former case, the more advanced forms of technology appear to be transferred in accordance to an overall international strategy. However, these transfers do not occur so readily in developing countries.

Canadian data produced by DeMelto *et al.* (1980b) indicate an average lag of about eight years between the first commercial launch of products or use of processes abroad and the first launch or use in Canada. When the data are restricted to imitative innovations transferred from an MNE to its Canadian subsidiary, the mean lag is 6.1 years for products and 5.1 years for processes. This pattern is similar to that reported by Mansfield and Romeo (1980) for all overseas subsidiaries in developed countries.

DeMelto *et al.* (1980a) also found that of 283 major Canadian innovations introduced between 1960 and 1979, 96 were based on externally controlled technology and in 54 per cent of these cases the technology was an intra-firm transfer from an MNE. These transfers were generally covered by agreements that allow the subsidiary full access to the R&D resources of the MNE.

Subsidiaries generally pay an annual fee (not specific to the technology transferred to the parent company). Eighty per cent of these agreements provided for a continuous transfer of technology. As the supplier develops better technologies in the relevant areas, it is made available to the recipient. About two-thirds give rights to sell; about three-quarters give rights to manufacture; about one-third specify the territory of sales (and in over 80 per cent of these cases, the firm is confined to selling only in Canada) (Mansfield 1985, p. 87).

Within MNEs, the costs in terms of time and resources appear to be considerably less than for arm's length transfers due to market imperfections, uncertainties and transaction costs. Indications are that foreign-controlled firms can obtain and transfer knowledge quickly and cheaply. Given the resource requirements and risks involved, it has been argued that:

With regard to many kinds of fundamental research, such countries [with open economies and relatively small domestic markets] would be well advised to "free ride" on the work performed in the biggest countries, at least to some extent, because the results of such work is disseminated rapidly and cheaply. Even in development, it seems eminently sensible for such countries to obtain many relevant technological capabilities through the multinational firms, even though the relevant developmental activities do not take place on their soil (Mansfield 1985, p. 97).

This prescription almost seems made to measure for the Canadian economy. However, it remains unclear whether the benefits from the transfers of technology to foreign-owned subsidiaries have or have not outweighed the costs in terms of potential growth and productivity improvements for the host country. In comparing the productivity of industries in Canada and in the United States, Saunders (1980) found a discrepancy of about 25 per cent for manufacturing. According to the Science Council (1984), high foreign control of industry in Canada has contributed to Canada's poor productivity performance. Foreign direct investment, which was initially attracted to Canada due to high tariffs, has not been affected by import competition when these tariffs were reduced, as might have been the case for domestic firms. "What this indicates is that the technological benefits associated with MNEs have been lost through the lack of competition in the Canadian market" (Science Council 1984, p. 30). On the other hand, recent

evidence suggests that Canada's lower productivity problems are due to trade restrictions and market size. These factors seem to have favoured small scale and short production runs, and have inhibited technology diffusion (see Economic Council 1983 and Baldwin and Gorecki 1985). It must be pointed out, however, that other studies on productivity differentials have been conducted, so far with either mixed or negative results (Caves 1985, p. 222).

This survey of the issues leads to a number of important observations:

- Multinationals (mostly U.S.-based) play a crucial role in Canada's high-technology sector.
- Based on economic considerations, these MNEs can reasonably be expected to appropriate to the maximum the returns from their firm specific advantage, be it technological knowledge or otherwise.
- MNEs will tend to centralize innovative activities in the home country to take advantage of economies of scale and maintain efficient supervision especially when this also happens to be the location of their largest market.
- Emphasis on increasing domestic levels of industrial R&D in order to better adopt, imitate or adapt MNE-generated technology might be well focused since, as Mansfield indicated, "From an economic point of view, it is much more important for a nation to exploit a new technology successfully than to be the first to introduce it." (Mansfield 1985, p. 98)

Multinational Enterprises and Employment

Because of the increasingly important role of MNEs, particularly in the area of product or process rationalization and technology transfers, multinationals have the potential to significantly affect the levels and the composition of employment worldwide. In 1981, the 500 leading MNEs employed almost 26 million people, accounting for more than 40 per cent of national industrial employment in nine of the wealthiest industrialized nations.

In Canada (usually a host country), nearly 30 per cent of manufacturing employment was provided by Canadian MNEs and 40 per cent by subsidiaries of foreign enterprises for a total of 70 per cent in the mid-1970s. Table 5.4 illustrates the importance of employment by foreign-controlled enterprises in 1981 in Canadian manufacturing industries where foreign ownership exceeded 50 per cent. As can be

seen, high-tech industries are very heavily represented among these with ratios of employment in foreign-controlled firms considerably higher than the average for all manufacturing.

There has been some concern in the U.S. over the employment impact of U.S. MNE operations following allegations, mainly from American labour unions, that through their expansion of manufacturing facilities abroad, MNEs were a vehicle for exporting U.S. jobs (Litvak 1981). Chaudhuri (1982), in his paper on U.S. MNEs and American employment, proposes a conceptual framework based on the product cycle theory and its links to FDI to explain the relationships involved. The fundamental issue underlying Chaudhuri's framework is the need to establish whether the location of production facilities abroad is necessary. Accordingly, it is considered that the foreign activities of MNEs involved chiefly in primary resources or services are necessary to either exploit the resources or service the markets where they are found. It is therefore in manufacturing activities that employment gains or losses are an issue.

The product cycle theory can be linked to employment in the MNE parent's country as follows:

Stage 1 – Innovation and development: these functions are served by high-tech (R&D) personnel. This stage also involves marketing the new product through market research, advertising etc.

Stage 2 – Large scale manufacturing begins for the domestic market. Increasing numbers of production workers will be required along with associated staff functions (accountants, auditors, quality control) and marketing functions to expand the market.

Stage 3 – Production increases to accommodate export markets. There is an increase in domestic blue- and white-collar employment.

Stage 4 – Foreign markets are supplied through foreign production which replaces export-related employment.

Stage 5 – Domestic markets are supplied from low wage, LDC production facilities when the production processes have become standardized and it is no longer necessary to use skilled labour. Production is shifted to minimize costs.

Table 5.4
Manufacturing industries in which foreign-controlled establishments employ more than half the total employees in Canada (1981)

Industry	No. of Employees	Percentage of employees
<i>Rubber and Plastics</i>		
Foreign		57.0
Canada		43.0
Total	61,504	100.0
<i>Machinery</i>		
Foreign		51.9
Canada		48.1
Total	108,531	100.0
<i>Transportation Equipment</i>		
Foreign		65.2
Canada		34.8
Total	178,162	100.0
<i>Electrical Products</i>		
Foreign		60.6
Canada		39.4
Total	127,924	100.0
<i>Petroleum and Coal Products</i>		
Foreign		85.5
Canada		14.5
Total	22,638	100.0
<i>Chemical and Chemical Products</i>		
Foreign		72.1
Canada		27.9
Total	90,427	100.1
<i>All Manufacturing</i>		
Foreign		37.2
Canada		62.8
Total	1,853,968	100.0

Note: Percentages have been rounded.

Source: Statistics Canada. *Domestic and foreign control of manufacturing, mining and logging establishments in Canada, 1981*, Cat. 31-401. Ottawa: 1985.

The employment effects involve three labour categories: high-tech personnel, white-collar employees and production workers. The high-tech personnel are involved in the innovation and development process. Their usage will start to drop during Stage 2 when the product is fully developed, problems have been ironed out and production stabilizes. From that point on, they are involved in maintaining the production process, in sales functions if the product is technically complex, and in consultant functions when plants are established abroad. The technical staff requirements will have "dwindled down to a skeleton" by Stage 5.

Employment of white-collar workers, on the other hand, is first associated with initial marketing in the middle of Stage 1. It will increase rapidly into Stage 2, still growing but at a slower pace during Stage 3. In Stage 4 there is likely to be a decline of the marketing and sales functions but not of centralized functions such as finance and accounting, which will still be provided through the home office. On the other hand, there will be an increase in white-collar employment to handle new national laws and environments. The white-collar group is not likely to be affected by the closure of production plants in Stage 5. Decreases in staff functions will be more than compensated for by the home-office support employment required to manage the subsidiaries abroad (Chaudhuri 1983, p. 266).

For production workers, employment begins with Stage 2 and rises sharply through this stage into Stage 3, where increases are not as rapid because exports are often a small fraction of domestic sales and because of the presence of overhead capacity. As production is shifted abroad (Stage 4), the decline begins. However, the net effect is not clear because of the "export stimulus effect" which occurs through:

- capital goods exports required to establish foreign production facilities;
- exports of intermediate goods and spare parts used in the production process and its maintenance in foreign subsidiaries;
- exports of complementary goods.

These factors actually increase in importance during Stage 5.

In discussing the total employment effect, it is necessary to determine if the FDI involved in Stages 4 and 5 is characterized by defensive or aggressive motives. Defensive motives are seen as a reaction to either anti-import policies in host countries, or competition from host country firms or from other MNEs producing in LDCs. This process inevitably goes from labour-intensive to capital-intensive so it can be assumed that if production is not moved to low wage countries,

domestic workers will eventually be replaced with automated assembly lines anyway.

Examples of aggressive foreign direct investment would include investing abroad to set up barriers to entry for native firms; setting up subsidiaries to appropriate monopoly rents from firm specific advantages such as a technical and marketing know-how; and shifting production to maximize global profits. "From a national point of view, aggressive foreign investment may be considered 'unnecessary' because it displaces American production workers and also hurts the short-term balance of payments situation" (Chaudhuri 1983, p. 271). On the other hand, if the motive was of defensive nature there is a perceived gain due to "the export stimulus effect for blue-collar workers and home office employment effect for white-collar workers" (Chaudhuri 1983, p. 273) because the alternative would have resulted in lost markets.

Studies indicate that in general, U.S. MNEs have pursued defensive strategies mainly to overcome tariff and trade barriers and to prevent competitors from pre-empting markets. The choice was not whether to produce domestically or abroad but whether to continue supplying the market abroad or withdraw.

In conclusion, Chaudhuri indicates that at the end of the product cycle, domestic employment *for that product* will have dropped even though there might be gains in white-collar employment. High-tech personnel will have to move to new products as will blue collar and eventually some white-collar workers. "The stability of employment due to the foreign sector in the U.S. economy would then depend on two things: a) steady 'waves' of new products, and b) similar market successes for each product to generate stable employment" (Chaudhuri 1983, p. 276). The author does not discuss the impact of the compression of the product cycle observed by Mansfield (1984).

The International Labour Office released a study in 1981 on the employment effects of MNEs in industrialized countries. The following findings were reported:

- Home-based employment of U.S. MNEs in the mid-1970s was 6.7 million, foreign subsidiary employment of U.S. MNEs was 3.3 million.
- The corresponding figures for Canadian MNEs were 540,000 and 360,000.
- In terms of production volume, investment and employment, the industrialized market economy countries remained the main area of MNE operation, accounting for three-quarters of the stock of all MNE investments.

- The foreign employment expansion of MNEs was not accompanied by a decrease in the employment volume in home country operations over the long-term.
- In general, however, case studies indicate a certain loss in manual jobs and an increase in white-collar jobs in home countries associated with MNE expansion abroad.
- Global trends tend to confirm that MNEs do contribute through international investment policy to the international restructuring of industry and employment, although they are only one of a number of factors involved.
- MNEs were found to constitute a particularly high proportion of activity and employment in industries that made intensive use of both technology and capital.

Transfer Pricing

Transfer pricing is the term used to describe the pricing of goods and services between divisions within a company.

These interdivisional transfers may include the flow of raw materials, intermediate goods, finished goods and a wide range of services. . . . Even in a purely domestic context where all the company activities are conducted in one country, transfer pricing is still vital to company profits and to the appraisal of divisional performance. Transfer pricing information may also affect many critical decisions concerning the acquisition and allocation of corporate resources. . . . In a multinational context, transfer pricing has often been viewed as an important means of transferring the funds and earnings of a multinational company in pursuit of various corporate objectives (Tang 1981, p. 3).

Transfer pricing becomes an issue when governments perceive that the transfer prices set by MNEs do not reflect market values and are a means of avoiding tax liabilities. As many studies have indicated, multinationals have both the opportunity and the incentive to use transfer pricing for tax advantage. The relative importance of this practice will be directly related to the difference in tax rates (for both direct and indirect taxes) and the taxation arrangements in place to

control transfer pricing in the relevant countries. However, by its very nature, transfer price manipulation is very difficult to monitor.

The issue of transfer pricing is of particular relevance to Canada. As Table 5.1 indicates, there is extensive foreign ownership in Canadian industry and indications are that the vast majority of exports and imports of foreign-owned Canadian corporations are to and from affiliates abroad (approximately 75 per cent in 1981). In fact, intra-firm trade could well account for over a third of Canadian merchandise trade and the figures do not even take into account the trading activities of Canadian MNEs. Also, because the industry distribution of inward FDI is relatively high-tech oriented, more royalties and fees tend to be payable to the home country, which adds a degree of flexibility for MNEs to remit earnings and transfer funds.

In a survey of 192 Canadian firms released in 1981, about 85 per cent of participants reported using transfer prices (Tang 1981). Among the determinants of international transfer pricing, overall company profits were listed as the most important. The main objectives appeared to be maximizing consolidated after-tax profits and evaluating divisional performances.

As indicated by Mathewson and Quirin (1979), when setting the optimum transfer price (to minimize tax payments) on specific merchandise, corporations face both tariff and corporate income tax considerations which tend to operate in opposite directions. For example, reducing a transfer price will reduce import duties but increase taxable income due to higher profits. "The conventional transfer pricing strategy under separate accounting is to overprice exports from and, underprice intra-firm imports to the low-tax country and vice-versa for the high-tax country" (Brean and Bird 1986, p. 30). In the absence of constraints, weighing the relative tax rates will enable the corporations to minimize the total tax burden. However, constraints are built in, particularly with respect to tangible goods where authorities are able, using "fair market value" or reasonable "benchmarks," to evaluate a particular situation and impose their own valuation for tax purposes (See Brean and Bird 1986). The range for price manipulation and the incentives to do so are therefore effectively restricted. However, the problems will be much more severe in the case of unfinished goods for which there is no apparent benchmark.

The principal conclusion of the Mathewson-Quirin study (1979) is that multinationals have a relatively restricted scope for transfer price manipulation. Abuse is more likely to occur in transactions in which the self-policing element introduced by offsetting incentives in the tax and tariff system is absent. The corporate services area is therefore likely to be more of a problem.

The implications of transfer pricing of intangibles are particularly of concern. These intangible transactions include the intercorporate payments for management services and access to research and development, royalties (for the use of patents and trademarks), and intercorporate loans. These naturally provide much more scope and flexibility in price setting, because a charge is made in exchange for a service which has no physical counterpart and the value of which is next to impossible to verify. For instance, Kopits (1976) estimates that about 25 per cent of royalty payments from industrialized countries represent concealed profit remittances.

According to Brean and Bird (1986), management fees and intracorporate lending provide the greatest potential for international profit shifting.

The legal restrictions in this area most affecting Canada are likely those initiated by United States tax authorities. Current U.S. tax law governing management services delivered abroad, for example, requires that foreign subsidiaries be charged a fee covering the direct expenses incurred by the parent and a share of indirect expenses (plus a mark-up of 10 per cent or more) which bears an appropriate relation to the profit margin on direct sales (Brean and Bird 1986, p. 18).

On the Canadian side regulations have been put in place to maintain the tax base and any other beneficial effects that may arise from the transfer pricing activities of MNEs. Deductions for management services received from foreign parents are restricted to the actual reimbursement of expenses and in cases where imputations are made, a 25 per cent withholding tax is applied. "An element of double taxation may thus exist with respect to management services delivered to U.S.-controlled subsidiaries operating in Canada." As for the problem of intercorporate lending which enables the MNE to shift interest deductions from a low-tax to a high-tax jurisdiction, it is addressed by Canada's "thin capitalization rule" which disallows interest deductions in cases where the subsidiary's indebtedness to the parent exceeds 75 per cent of total subsidiary finance.

Brean and Bird add that "[d]espite the sometimes aggressive tone of such rules, the large number of options open to international tax planners invariably gives the edge to the multinational corporation" (p. 11). By its very nature transfer pricing is difficult to pinpoint and assess. As a result "even in sophisticated countries such as Canada, tax officials have been increasingly troubled by their inability to obtain the full picture with respect to international transactions and their consequent feeling that, for some taxpayers at

least, the extent to which they pay taxes in Canada has become largely a voluntary act" (Brean and Bird 1986, p. 68).

There is no empirical evidence as to the direct impact of transfer pricing on Canada's tax base or balance of payments. However, studies such as that by Deutsch and Jenkins (1982) indicate that Canada has probably benefited from the corporate tax rate differentials between Canada and the United States, the U.S. foreign tax credit and the ability to defer subsidiary earnings repatriation and the accompanying U.S. tax liability. Recent survey results based on Bishop and Crookell's (1986) study of specialization and foreign investment in Canada tend to confirm these observations. It appears that "the most significant parent policy recurring across the sample was a willingness to reinvest affiliate earnings in Canada, and to forgo or postpone dividend remission to the United States" (p. 334). Furthermore, because (in general) only negligible cross-border payments are made to parents for technology and management fees, there has been a reduction of affiliate borrowing needs. Bishop and Crookell conclude that overall respondents tended to favour transfer prices based on a clear formula to avoid possible queries from tax authorities on both sides of the border and also that "Canadian affiliates seem to benefit from technology inflow for which they could be required to account and pay to a much larger extent than they do" (p. 336). The authors add, however, that the trend towards greater integration with the parent through rationalized production and product mandating may increase the importance of transfer pricing policy. Finally, the nature of the changes brought on by the U.S. Tax Reform Act of 1986 in particular those relating to the foreign tax credit and the lower corporate tax rates could very well generate some significant adjustments on the part of MNEs.

Aside from tax regulations, there might be an even greater constraint limiting MNEs' scope for transfer pricing manoeuvres. This constraint relates to the fact that transfer prices are in essence a "shadow price" within the firm which enables it to allocate resources efficiently. Given that large firms are not likely in a position to keep two sets of books, "the transfer prices used to affect profits reported to the tax collector also determine the profits perceived by the firm's division managers to flow from its various activities" (Caves 1985, p. 246). The firm, in seeking to maximize global profits, will have to take into account these goals, which are not necessarily compatible.

The issue of transfer pricing is really one of market imperfections. On the one hand, governments can impose taxes, regulations and other market restrictions while MNEs are able to use transfer prices (to a degree) in order to overcome these restrictions. On the other hand, there are cases where external markets do not exist or are inefficient (such as that for knowledge as an input) and

MNEs are in a position to create an internal market which is "efficient." It has been argued that the use by MNEs of shadow prices to clear transactions among its divisions is efficient and therefore raises global welfare when used to price intangibles for which regular markets do not exist and when used in response to government-imposed market imperfections such as taxes and tariffs. But as pointed out earlier, because of the necessity to trade off between the gains from minimizing tax payments and the resulting loss from misallocated resources, the maximizing transfer price might differ from the shadow price and no longer be efficient (See Rugman and Eden 1985).

Nevertheless, the question remains whether transfer prices should be compared to arm's length competitive prices either in evaluating the efficiency of transfer prices or as a standard by tax authorities to value intra-firm transfers. Two important considerations must be taken into account in this respect. First, the nature of intra-firm transactions is such that many of the transfers involve intangibles (for example, technical and management know-how) for which no market prices can be observed. Second, the divisions of an MNE do not operate as independent profit centres. They are, in fact, part of a larger, integrated system. On those grounds, it appears that there is often no efficiency rationale for using arm's length standards. However, other authors such as Shoup have argued that, leaving aside the efficiency issue, using the arm's length principle is "still necessary to ensure a fair international distribution of the MNE's world-wide income" (Rugman and Eden 1985, p. 9).

World Product Mandates

Traditionally, MNE operations in Canada have consisted of branch plants that produce a wide array of products, each in relatively small quantity because of the size of the market and trade barriers. Branch plants have therefore been unable to take advantage of economies of scale. The import-substituting nature of MNE operations in Canada has also meant that there has been little need for foreign MNEs to undertake R&D in Canada.

However, there have been dramatic changes in the Canadian competitive environment which have, in essence, changed the rules of the game. These changes include the fluctuations in currency values, the trend towards significant export incentives in Canadian industrial policy and, more important, the move toward freer trade as tariff levels continue to decline as a result of the GATT Tokyo round of negotiations. Because these changes indicate a trend towards a more competitive climate, it seems unlikely that the miniature replica subsidiary or the import-substituting mode of operation of MNEs will

remain a preferred option. The way in which MNEs will respond to this new environment could transform the structure of Canada's secondary industry.

Two options are available. The first is to cut down on Canadian operations and service the market from other plants probably in the U.S., especially if excess capacity exists. The second, considered by many to be more likely and more in line with observed global trends, consists of rationalizing international operations (Stopford and Dunning 1983). Such an approach would involve reducing production costs and increasing exports by manufacturing fewer products in longer runs in Canada to supply the entire North American or world market while importing the balance of the product line into Canada.

There appears to be a lack of consensus as to which of these options is likely to prevail in the long run. U.S. FDI in Canada was undertaken to get behind tariff barriers or to accommodate Canadian government procurement regulations. For the most part, the branch plant policies and strategies have consisted of minimizing plant and equipment expenditures, relying to a great extent on imports or local procurement and engaging in R&D only to the extent necessary to satisfy local restrictions and demands. Increases in local procurement and manufacture of products for exports have been mostly the result of additional Canadian requirements and regulations. Added to these arguments is the fact that Canadian plants have, on average, been up to 30 per cent less productive than U.S. plants. Furthermore, there has been a trend towards moving offshore assembly plants back to automated computer-integrated facilities in United States.

On the other hand, survey results produced by Daly and MacCharles (1986) and Bishop and Crookell (1986) suggest that, in general, foreign firms are not likely to cut production in Canada. Not only are existing capital equipment, suppliers, managers and employees logistically difficult to part with, but the surveys also suggest that there is "a deep aversion to closing down production facilities in both Canada and the United States" (Bishop and Crookell 1986, p. 343). Furthermore, there are some very strong forces in the market-place that make such an option unappealing. For example, domestic manufacturers tend to secure a larger market share than importers.

Although the rationalization approach would seem better from Canada's point of view than the opting out alternative, the net benefits in terms of our balance of trade, and more important, of our innovation potential, are not clear. Authors have pointed at the farm equipment industry and the automotive industry as prime examples of the implications for Canada of product or process rationalization.

According to Bishop and Crookell (1986), although the rationalization of the automotive industry led to gains in labour and capital

productivity, the costs involved a greater centralization of management and technology and an oscillating and sensitive balance of trade. In the case of farm equipment, the overall effect on the Canadian balance of payments has probably been negative in the context of U.S. multinationals and positive in the case of Massey-Ferguson.

The host country does not usually do all that well from rationalization. It tends to inherit a factory rather than a business and a sales force rather than a marketing group. What it produces and what it sells are two different things and, while it exports heavily, it does not engage in export marketing. Firms engaged in rationalized production operate through a powerful central headquarters that controls output levels and links them to market requirements. The subsidiaries are a poor breeding ground for general management and are often deficient in R&D. To be more accurate, they are usually deficient in product design and development because they do not normally receive continuing market feedback. They may, in contrast, be very proficient in process-technology improvements and may devote a considerable R&D effort to this end (Bishop and Crookell 1986, p. 312).

The concept of world product mandating (WPM), which can be considered as either an alternative to or a more comprehensive form of rationalization, has been lauded by the Canadian government's Export Promotion Committee, the Ontario government's Advisory Committee on Global Product Mandating and the Canadian Science Council as an option that holds many advantages for all parties concerned. More important, it has great appeal to Canadian subsidiary managers and Canadian government officials because by definition it stands to make Canadian plants internationally competitive and could improve Canada's research and development capability.

In its pure form, a global product mandating strategy involves assigning to a subsidiary total responsibility for all aspects of research and development (R&D), production, and international marketing on a worldwide basis with respect to a product or group of products. In practice, however, some functions are often retained by the parent or given to sister subsidiaries located in various parts of the world. The mandate can also be limited to a particular group of countries (Wolf 1983, p. 91).

There are, therefore, several kinds of WPMs that can be considered. These differ in relation to the level of risk to the parent and the level of control maintained by the parent (Poynter and Rugman 1982, p. 60). One variation is full WPM, in which all functions related to the product are carried out by the subsidiary and control includes product renewal, evolutionary products, growth rates, exports and other strategic policies. Another variation is partial WPM, in which the subsidiary will more likely carry out at least some R&D and total production but where international marketing and remaining policies are under parent control. A third variation is a production mandate, whereby the subsidiary carries out production but R&D, if undertaken, is limited to product or process development and all strategic management occurs at parent level. For the positive effects considered to be associated with WPM to occur, it is generally agreed that at least a partial type of WPM is required. Because of the risks and costs associated with full WPMs, partial WPMs are also more likely to be implemented. Essentially, the decision to adopt a WPM strategy remains with the parent firm and depends on a number of variables.

It is generally agreed that the onus is on the subsidiary's management to promote and justify the feasibility of the WPM as a preferable option for the enterprise as a whole. But corporate headquarters management must also be receptive to the idea, a product line demarcation must be able to be established, and some autonomy must be granted to the subsidiary.

The issue of efficient decentralization of R&D is important. The extent of scale economies involved is undoubtedly a factor although studies have found that the problem is in keeping the proper balance between autonomy and control and that decentralization obviously complicates the nature of the control relationship between corporate headquarters and R&D (Fischer and Behrman 1979). It has also been suggested that although the early stages of R&D may be incompatible with WPM, the later stages are perhaps more suitable. According to the theory of internalization, the firm will prefer to control its specific advantage and decentralization will be viewed as a costly risk.

Other costs which will also be considered are those associated with restructuring the subsidiary from an import-substituting operation to a rationalized one versus the costs of closing existing facilities. The relative costs of production, transportation and communication versus those of other locations will be examined. To the extent that WPMs are incompatible with trade impediments, low tariff rates and special duty remission agreements will be factors encouraging WPMs. Indications are that government incentives may also play a significant role by providing R&D and employment subsidies, tax incentives and favoured government procurement

status. These factors have already come into play in setting up a number of present mandates.¹

An important point emphasized by Bishop and Crookell (1986) in their extensive study of specialization and FDI in Canada is that the WPM alternative is not applicable in all circumstances. Some product market considerations and organizational maturity come directly into play. As the authors indicate, the MNE that faces continuing increases in global competition and freer trade internationally has a number of options concerning its Canadian operations, and mandating is only suitable under some circumstances.

One might speculate that firms making only one major product may be inclined either to pull out of Canada or to continue as miniature replica subsidiaries, depending on the magnitude of scale economies in their product line. Multi-product firms appear to offer the best potential for rationalization or mandating, although a single product line with many models – automobiles, for example – may be a good candidate for rationalization but not for mandating. Mandating seems to require a bite-sized piece of business in the form of a product line with good development potential and aggressive management in the subsidiary. Products that are integrated into continuous-flow production processes or that are marketed in tandem with other products would not be good candidates for mandating (Bishop and Crookell 1986, p. 320).

As described by Etemad (1983), from the parent company's viewpoint, the WPM could imply a reduction in risk associated with developing new technology, marketing and investing. Reduced friction and conflict with the host government is also likely to occur. On the other hand, some implicit costs must be acknowledged, such as:

Loss of bargaining power as a result of reduced sourcing flexibility and substantial, if not total, reliance on the mandate holder, suppliers, labour unions and, at times, the host government.... Although increased external control of the parent [through increased dependence of the subsidiary for external markets] can partially compensate for the loss of bargaining power and its associated disadvantages, in the longer run, there is no substitute for this loss in the short run (Etemad 1983, p. 122).

The main features of a full WPM as summarized by Etemad are shown in Table 5.5. In essence, these relate to the benefits arising from

economies of scale, international competition and basic research and development activities. Some concern has been expressed in the literature that the government might get carried away with the potential virtues of WPMs and allocate too many resources to favour the use of this approach (Wolf 1983), (Crookell and Caliendo 1980).

Again, it must be emphasized that the decision to adopt such a WPM strategy remains at the parent firm level. The basic elements at play in this process are fairly straightforward:

The essence of the WPM decision from the viewpoint of the centralized multinational is the trade-off between a) having the full control of key functions and strategic decision making (no mandating) and b) mandating activities with possible host nation subsidies but with potential loss of control through decentralized research and development, strategic management and product marketing. The choice made by the multinational will depend upon an evaluation of i) the relative size of the host government incentives, ii) the disadvantage of losing control by decentralization of several strategic management functions (WPM) and iii) the long run prospects for the performance of an autonomous-mandated-subsidiary and its probable contribution to the profits of the multinational (Poynter and Rugman 1982, p. 59).

Rugman and Douglas (1986) say the essential ingredients of WPM are also those that generate the greatest costs in terms of the potential loss of control on the part of the parent. These are: (1) the transfer of R&D capability, (2) transfer of responsibility for seeking future associated products and market niches, and (3) worldwide marketing functions. Although several WPMs have been granted to Canadian subsidiaries by multinational parents (Pratt and Whitney, Black and Decker, Westinghouse and GE), "the optimism that followed these early cases became more cautious when it was realized that the number of firms planning to engage in this practice was very small and that their overall impact on Canada would be equally small" (Papadopoulos 1986, p. 79). The reasons for this relate to the three ingredients mentioned above. Research shows that formal strategic planning within the multinational firm is done mostly at the parent level. Furthermore, since most Canadian plants of U.S. MNEs are truncated subsidiaries and since the parent already has extensive operations in Western Europe, there is little incentive to develop these markets from their Canadian base (see Papadopoulos 1986). Finally, the international distribution network which the parent firm already has in place reduces the significance of the world mandate for the

Table 5.5
Main Features of a Mature World Product Mandate
in the Host Country

WPM allows for economies of scale, economies of learning and optimum scale (optimum batch sizes or economical plant sizes).

WPM provides for more efficient operations resulting in lower unit costs that enhance competitiveness.

WPM creates maximum employment which is not dependent on local trade barrier or local protection.

WPM may have local content ratio (or local value added) as high as 100 per cent.

Given the optimal scale of operation, buy/make decisions are expected to be in favour of equally efficient operation which is an incentive for local related industries to follow suit and gear up to supply components or subassemblies to the WPM.

Possibility of transfer pricing disputes, because of purchasing of such components from abroad, will be minimized.

High exports combined with low imports will have a positive effect on the host country's balance of payments.

There will be every incentive to support the continual viability of the mandate by extensive R&D at the subsidiary level.

Given the benefits to the host and the need for continuing R&D to support the mandate, R&D's high costs and risks are expected to be partially borne by the host country and indeed the mandate holder may become a future exporter of technology as well as of the mandated product.

Through other sister subsidiaries, the mandate holder develops access to international markets and by virtue of the open market competition, it will be constantly forced to remain competitive on the world basis.

Table 5.5 (continued)
Main Features of a Mature World Product Mandate
in the Host Country

Because of economies of scale and learning, the mandate holder is supposed to become a competitive supplier of mandated product on the world market.

There is no logical reason for the mandated product to apply any upward cost and price pressure on this industry or the market. Indeed, there will be some downward pressure.

There will be a concentration of effort on the manufacturing, marketing and improvement of the mandated product.

Since the efficiency of mandate is based on extensive exporting, the fear and suspicion about lack of exporting effort disappears.

As opposed to disagreement between the host government and the subsidiary on intention or ability to export, both will cooperatively try to enhance the subsidiary's substantial competitiveness to be able to export continually.

The adversarial relations causing disagreement, friction and conflict between the host government and the MNE/subsidiary is bound to be replaced by more supportive and cooperative relationship.

Source: Etemad, H. "World Product Mandating in Perspective," in Rugman, A., (ed). *Multinational and Technology Transfer*, 1983, p. 114.

subsidiary by limiting its decision-making autonomy and the gains from being able to conduct international marketing activities. The importance of this network is only likely to increase since, with an increasingly competitive global marketplace, MNEs need to achieve economies of scope as well as economies of scale.

Notes

1. See Science Council (1980) for a description of the implementation of WPM in Canada in four foreign-owned subsidiaries, Black and Decker, Westinghouse, Garrett Manufacturing and Litton Systems.

Chapter VI

Measuring High-Tech: Conceptual and Statistical Problems

Introduction

During 1985 and 1986, the issue of high-tech trade received a great deal of attention in the Canadian media, and some of the country's larger newspapers featured articles on the subject. For the most part, these articles bemoaned Canada's rising deficit in trade of high-technology products and, more important, predicted that this situation was unlikely to improve, at least not in the near future. Statistics Canada figures estimated the value of this deficit at \$12 billion in 1984, and \$12.5 billion in 1985. According to the Ministry of State for Science and Technology (MOSST), Canada's trade deficit in high-tech products is the worst among the Economic Summit countries (MOSST 1985). Canada is also the only major industrialized country with a trade deficit in all high-tech commodity groups. The country's performance, in market share of OECD exports of research and development (R&D) intensive products and in gross expenditure on R&D as a percentage of the gross national product (GNP), is equally unimpressive.

Members of Canada's science and technology community have been quite alarmed by these figures (see Toronto Star 1986). They question the country's long-term ability to compete in world markets and maintain its standard of living. Canada is viewed as being dependent on foreign sources to obtain the high-tech products it requires. Its access to new technology is thereby limited to some

extent, and it cannot capitalize on the positive aspects of high technology production.

However, upon closer examination, it is not clear that these indicators tell us very much about Canada's competitiveness in the area of high technology. To begin with, the estimates of a high-tech trade deficit are based on trade data that are subject to inconsistencies at the valuation and the classification levels. Certain characteristics of high-tech trade, such as the importance of interaffiliate trade and the rapid pace of product evolution, indicate that these problems are likely to be more severe in the high-tech product categories. This leads us to the methodology issues underlying high-tech trade estimates. An assessment of the latter is necessary to determine the information that can be derived from these indicators.

For instance, it is important to realize that there is not a widely accepted definition of what constitutes a high-tech product or a well established methodology that can be used to identify these products. As a result, significant discrepancies between high-tech trade estimates are found.

In terms of Canada's technological competitiveness, the information not conveyed by the high-tech trade estimates is more important than the information that is. For instance, not only does technology manifest itself at the final product level, as described by its function, but also in the production process, the equipment and the inputs used to produce the technology. High-tech products also differ in their level of economic impact. Here the distinction between consumer goods, production equipment, and production inputs would be particularly useful. Attempts to measure technology embodiment may be more instructive from the public policy perspective than the current estimates of high-tech trade.

This chapter describes the statistical and methodological problems encountered in estimating Canadian high-tech trade and discusses some of the conceptual issues involved in evaluating a country's performance in technology. Trade in high-tech products is only one channel through which technology is transferred between countries. In the last section of this chapter, we look at some of these other channels and describe the measurement problems involved in estimating the balance of technological payments.

Canadian Trade Data: Classification and Valuation Issues

Before undergoing any analysis of specific trade estimates, some issues and concerns that relate to the basic trade data should be pointed out. For instance, it is important to realize that the published data classifications for exports and imports are not strictly

comparable. All Canadian merchandise trade data originate from Revenue Canada customs documents. On the import side, importers are required to assign fairly detailed classification codes to determine the amount of customs duties applicable. But on the export side, the information collected is not nearly as precise or comprehensive and the classification codes themselves are usually assigned by Statistics Canada officials.¹ As a result, the published data are much more detailed on the import side (2,700 commodity classes). The estimates are usually published at the five-digit level with the seven-digit detail available on request. The export data, on the other hand, are assigned only five-digit codes, and in many cases, this data is aggregated further before publication because of confidentiality considerations. There are only 1,200 export commodity classes.

The Canadian trade classifications have not been updated for several years (1977) and, as a result, are not always adequate in collecting data that reflect current trade patterns and production trends. This problem is undoubtedly much more severe in the high-tech area where innovation and the steady development of new technology result in the emergence of new products which render others obsolete at a fairly rapid pace. The survey by the Institute for Research on Public Policy (IRPP) of some of the computer manufacturers indicates that fitting products in the present categories has been a problem for many of the larger companies, especially with the trend towards integrated systems.

Another factor to keep in mind when analyzing the trade data in office machinery is the impact of various tariff rates and customs regulations on the type of products which are reported as traded. Telecommunications equipment is subject to a 17.8 per cent import duty when it enters Canada. The applicable rate on computer equipment is 3.9 per cent, while under an agreement between the United States, Canada and Japan, computer parts were, until recently, exempt from duties. We understand that these very different customs treatments do affect whether products are brought in as assemblies, parts or sub-components.

A final consideration that should be mentioned is the valuation basis. Until January 1985, the value assigned to imported goods was the customs value for duty based on the "fair market value." With the growing importance of international corporations, and the fact that a substantial portion of Canadian trade occurs between Canadian subsidiaries of foreign companies and their foreign affiliates, a growing concern was that values assigned for customs duty purposes differed considerably from the actual transaction receipts or payments. The Canadian customs valuation system was also considered to be inconsistent with the rules of the General Agreement on Tariffs and Trade (GATT) on this subject. For these reasons, the

basis of valuation for imports was changed to actual transaction values that are based on the GATT valuation code (see Salembier *et al.* 1987, p. 111). This eliminated a potentially serious discrepancy between the value of exports and imports. Some of the computer companies interviewed by the IRPP estimate the new valuation basis will deflate import values for certain products by as much as 25-50 per cent.

A more complex problem with valuation concerns the issue of transfer pricing, particularly in sectors where intra-firm transactions are prominent, such as in the trade of office machinery and several other products conventionally defined as high-tech. For instance, Stopford and Dunning (1983) indicate that in 1977, over 91 per cent of total exports of office equipment (including computers) by parent multinational enterprises (MNEs) in the United States, were dispatched to their own affiliates.² The issue of transfer pricing was discussed in more detail in Chapter V. Although MNEs have both the opportunity and the incentive to utilize transfer pricing, government enforcement measures to control tax avoidance and the necessity for MNEs to use transfer pricing to measure performance and allocate resources efficiently, significantly limit the scope for price manipulation on the part of MNEs. It can also be said that the flexibility to use transfer pricing is probably greater in transactions that involve intangibles (such as charges for technical information and management services) than in the trade of specific goods.

The updated, harmonized system of trade classification of the Brussels Customs Cooperative Council Nomenclature (CCCN) is expected to be adopted in Canada by January 1988. The possible across-the-board elimination of tariffs under a freer trade agreement with the United States, along with the expected changes, both in valuation and classification systems, should provide us with internally consistent and internationally comparable trade data. However, present trade estimates are still subject to all the considerations mentioned above.

The Balance of Trade in High-Tech Products

a) The Data

Estimates of the high-tech trade deficit reported in the newspapers, as well as in the MOSST discussion paper (1985), are those published by the Science, Technology and Capital Stock Division of Statistics Canada (STD).³ STD has reclassified Statistics Canada's estimates of manufacturing trade by technology group to calculate the value of exports, imports and trade balance for the following categories:

- High technology commodities (chemicals, office machinery, other machinery, aircraft and parts, electrical products and scientific instruments).
- Medium technology commodities (organic chemicals, small manufacturing machinery, transportation equipment etc.).
- Low technology commodities (food and food products, clothes, furniture, printed material etc.).
- Motor vehicles.
- Resource-related manufactured products (wood and paper products, fertilizers, iron and steel products and non ferrous metal products).

Tables 6.1 to 6.3 report the estimates of exports, imports and balance of trade by technology group from 1968 to 1984. For several years, the value of exports of high technology products has always ranked third, behind that of motor vehicles and parts and resource-related products, although the values for these two categories are substantially higher (approximately 2 to 2.5 times higher). On the import side, however, the value of imports of high technology products was the largest of all categories from 1980 to 1982, and the second largest in 1983-1984 when imports of motor vehicles and parts took a relatively small lead.

The balance of trade figures reported in Table 6.3 show a \$12 billion deficit for high technology products in 1984. This marks a sharp increase, of 28 per cent, since 1983. As the figures show, there had been steady increases in the deficit until 1981. The numbers for the past few years are a little more volatile. The only year where a decrease was experienced in the high-tech trade deficit was 1982. The decrease was mainly due to a drop in the value of imports of high-tech products for that particular year. However, this was followed by substantial increases in the 1983 and 1984 deficit and the figure released for 1985 (\$12.5 billion) indicates more of a holding pattern.

These balance of trade figures by technology group, taken at face value, tend to confirm the "hewers of wood and drawers of water" theory of Canadian trade. For 1984, for example, the combined trade deficit in high- and medium-tech commodities totalled \$18 billion. This deficit was compensated to a large extent by the \$15.3 billion surplus in trade of resource-related products although trade across manufactured products did result in a \$4.3 billion deficit in 1984. The \$14.6 billion merchandise trade surplus for Canada in 1984 was accounted for mainly by large surpluses experienced in non-manufacturing sectors, notably \$8.6 billion for energy products, \$7.9

Table 6.1
Exports of Manufactured Products, by Technology Group,
Canada, 1968-1984

Year	High Technology Products	Medium Technology Products	Low Technology Products	Resource- related Products	Motor Vehicles and parts	Total
millions of dollars						
1968	1 240	436	1 217	3 597	2 746	9 236
1969	1 339	513	1 365	3 776	3 514	10 507
1970	1 533	572	1 656	4 365	3 499	11 625
1971	1 537	555	1 783	4 074	4 171	12 120
1972	1 800	696	2 007	4 288	4 178	13 509
1973	2 058	1 107	2 589	5 173	5 415	16 252
1974	2 491	1 238	2 669	7 346	5 717	19 461
1975	2 887	1 408	2 915	6 919	6 433	20 562
1976	3 202	1 766	3 417	8 254	8 224	24 863
1977	3 591	1 895	3 813	9 425	10 424	29 148
1978	4 904	2 493	4 817	11 430	12 540	36 184
1979	6 639	4 033	6 069	13 766	11 900	42 407
1980	7 962	4 903	6 537	18 290	10 818	48 510
1981	9 375	5 024	8 281	18 548	13 084	54 312
1982	9 111	5 164	7 987	16 441	16 518	55 221
1983	9 101	5 173	8 063	16 873	21 357	60 567
1984	11 488	6 415	9 035	20 791	29 404	77 133

- High technology commodities (chemicals, office machinery, other machinery, aircraft and parts, electrical products and scientific instruments).
- Medium technology commodities (organic chemicals, small manufacturing machinery, transportation equipment, etc.).
- Low technology commodities (food and food products, clothes, furniture, printed material, etc.).
- Motor vehicles.
- Resource-related manufactured products (wood and paper products, fertilizers, iron and steel products and non-ferrous metal products).

Source: Statistics Canada. Science, Technology and Capital Stock Division.
Technology and Trade Statistics: Part 1. June 1985.

Table 6.2
Imports of Manufactured Products, by Technology Group,
Canada, 1968-1984

Year	High Technology Products	Medium Technology Products	Low Technology Products	Resource- related Products	Motor Vehicles and parts	Total
millions of dollars						
1968	2 813	1 721	1 942	750	3 001	10 227
1969	3 235	2 009	2 325	950	3 546	12 064
1970	3 290	2 011	2 370	860	3 252	11 782
1971	3 505	2 066	2 595	981	4 110	13 257
1972	4 157	2 603	3 105	1 137	4 934	15 946
1973	5 157	3 303	3 784	1 449	6 081	19 774
1974	6 614	4 575	4 773	2 459	7 124	25 545
1975	7 319	4 780	5 090	2 062	8 237	27 486
1976	7 811	4 972	5 889	2 010	9 440	30 120
1977	8 665	5 672	6 398	2 154	11 576	34 464
1978	10 768	6 997	7 516	2 780	13 386	41 448
1979	13 951	8 670	9 135	4 702	15 161	51 619
1980	16 120	9 531	9 359	5 047	13 479	53 535
1981	19 078	10 671	10 110	5 801	15 996	61 657
1982	16 762	8 837	10 016	3 851	15 124	54 590
1983	18 468	10 101	11 170	4 606	19 315	63 660
1984	23 462	12 529	13 488	5 529	26 460	81 468

Source: Statistics Canada. Science, Technology and Capital Stock Division.
Technology and Trade Statistics: Part 1. June 1985.

Table 6.3
Balance of Trade in Manufactured Products, by
Technology Group, Canada, 1968-1984

Year	High Technology Products	Medium Technology Products	Low Technology Products	Resource- related Products	Motor Vehicles and parts	Total
millions of dollars						
1968	-1 574	-1 285	-725	2 847	-255	-992
1969	-1 894	-1 495	-960	2 827	-32	-1 554
1970	-1 755	-1 439	-713	3 504	247	-156
1971	-1 967	-1 512	-812	3 093	61	-1 137
1972	-2 369	-1 907	-1 097	3 151	-216	-2 438
1973	-3 100	-2 286	-1 194	3 724	-666	-3 522
1974	-4 120	-3 338	-2 103	4 886	-1 408	-6 083
1975	-4 433	-3 371	-2 175	4 857	-1 804	-6 926
1976	-4 607	-3 205	-2 471	6 244	-1 215	-5 254
1977	-5 073	-3 777	-2 585	7 272	-1 152	-5 315
1978	-5 864	-4 504	-2 699	8 650	-846	-5 263
1979	-7 312	-4 637	-3 066	9 064	-3 261	-9 212
1980	-8 157	-4 628	-2 821	13 243	-2 661	-5 024
1981	-9 705	-5 647	-1 829	12 747	-2 912	-7 346
1982	-7 652	-3 673	-2 029	12 590	1 394	630
1983	-9 349	-4 928	-3 107	12 267	2 042	-3 075
1984	-11 974	-6 114	-4 453	15 262	2 944	-4 335

Source: Statistics Canada. Science, Technology and Capital Stock Division.
Technology and Trade Statistics: Part I. June 1985.

billion for natural resources and raw materials and \$3.0 billion for agricultural products.

Tables 6.4 to 6.6 report the value of exports, imports and balance of trade of high technology products by product group. Office machinery accounts for approximately 12 per cent of exports and 19 per cent of imports of high-tech products. On the export side, office machinery and scientific instruments are the smallest product groups, while on the import side, office machinery ranks third behind electrical products and other machinery. The electrical products category is the largest contributor to the 1984 negative balance of trade in high-tech products (27 per cent) followed closely by office machinery (25 per cent), and other machinery (22 per cent). The balance of trade estimates for office machinery indicate a relatively significant increase in the deficit (46 per cent) from 1983 to 1984. Data show that when receipts and payments are deflated by the implicit price indexes for exports and imports, increases in the value of trade (both imports and exports) of office machinery have been considerably more important than for any other high-tech product category.

b) Conceptual and Methodological Problems

The balance of trade figures for high technology products reported in Table 6.6 consist of net trade estimates for a series of manufactured products which have been classified as "technology intensive." Estimates of this type have attracted a lot of interest as a way of gauging the economic performance and the prospects of individual countries. "The production and export of high-tech products are widely seen as critical to the economic growth and international competitiveness of industrialized and some developing countries" (U.S. Department of Commerce 1985b, p. 61). In Canada, the view expressed is that "anything that a government can do to improve a nation's balance of trade in high technology products will profoundly affect that nation's basic wealth, standard of living and general progress. Knowledge of the trends of that trade overall and in its components is an essential precondition for intelligent action" (Statistics Canada, Cat. 88-503E, p. 29).

This "we've got the technology" syndrome seems to have evolved from research such as that reported in the MOSST discussion paper where R&D intensity (one of the main criteria used to characterize technology) is linked with relatively higher levels of value added, productivity and employment as well as larger volumes of shipments, in particular exports. Canada's poor performance among OECD countries in comparing indexes of creativity, productivity and market share of exports of high R&D products, is perceived to be a

Table 6.4
Exports of High Technology Products, by Product Group, Canada, 1968-1984

Year	Chemicals	Office Machinery	Other Machinery	Aircraft and Parts	Electrical Products	Scientific Instruments	Total
	millions of dollars						
1968	164	50	312	369	248	97	1 240
1969	197	71	360	331	262	118	1 339
1970	230	114	378	380	294	137	1 533
1971	243	147	407	332	282	126	1 537
1972	271	184	438	476	289	142	1 800
1973	345	205	532	414	389	173	2 058
1974	423	217	766	433	462	190	2 491
1975	442	273	1 054	422	463	233	2 887
1976	636	332	1 022	453	505	254	3 202
1977	759	347	1 200	486	531	268	3 591
1978	1 183	475	1 447	691	735	373	4 904
1979	1 540	642	1 928	1 005	1 017	507	6 639
1980	1 777	739	2 137	1 403	1 281	625	7 962
1981	2 035	874	2 598	1 497	1 651	720	9 375
1982	1 789	928	2 165	1 732	1 679	818	9 111
1983	1 813	1 068	1 871	1 520	1 877	952	9 101
1984	2 283	1 377	2 109	1 781	2 902	1 036	11 488

Source: Statistics Canada. Science, Technology and Capital Stock Division. *Technology and Trade Statistics: Part 1*. June 1985.

Table 6.5
Imports of High Technology Products, by Product Group, Canada, 1968-1984

Year	Chemicals	Office Machinery	Other Machinery	Aircraft and Parts	Electrical Products	Scientific Instruments	Total
millions of dollars							
1968	323	200	919	437	505	429	2813
1969	386	268	1 032	401	637	510	3 235
1970	462	314	975	384	619	535	3 290
1971	435	368	1 122	289	738	554	3 505
1972	500	447	1 352	294	949	625	4 167
1973	599	497	1 627	511	1 165	757	5 157
1974	889	609	2 175	667	1 362	913	6 614
1975	806	659	2 857	695	1 296	1 006	7 319
1976	919	736	3 089	406	1 602	1 058	7 811
1977	1 119	798	3 173	433	1 843	1 293	8 665
1978	1 268	1 075	3 714	840	2 258	1 613	10 768
1979	1 531	1 348	4 982	1 364	2 764	1 962	13 951
1980	1 554	1 903	5 470	1 828	3 007	2 357	16 120
1981	1 802	2 582	5 972	2 347	3 669	2 708	19 080
1982	1 675	2 867	4 483	1 523	3 489	2 726	16 762
1983	2 100	3 111	4 077	1 814	4 454	2 914	18 468
1984	2 520	4 365	4 727	2 230	6 101	3 518	23 462

Source: Statistics Canada. Science, Technology and Capital Stock Division. *Technology and Trade Statistics: Part 1*. June 1985.

Table 6.6
Balance of trade in High Technology Products, by Product Group, Canada, 1968-1984

Year	Chemicals	Office Machinery	Other Machinery	Aircraft and Parts	Electrical Products	Scientific Instruments	Total
millions of dollars							
1968	-160	-150	-607	-68	-257	-332	-1 574
1969	-189	-197	-672	-69	-375	-392	-1 894
1970	-232	-200	-597	-4	-325	-397	-1 755
1971	-192	-220	-715	43	-455	-428	-1 967
1972	-230	-263	-914	181	-660	-483	-2 369
1973	-254	-292	-1 096	-97	-777	-584	-3 100
1974	-465	-391	-1 409	-234	-899	-722	-4 120
1975	-364	-386	-1 803	-274	-833	-773	-4 433
1976	-283	-404	-2 067	48	-1 097	-804	-4 607
1977	-360	-451	-1 973	47	-1 311	-1 025	-5 073
1978	-85	-600	-2 267	-149	1 523	-1 240	-5 864
1979	9	-706	-3 054	-359	1 747	-1 455	-7 312
1980	223	-1 164	-3 333	-425	-1 762	-1 732	-8 157
1981	223	-1 708	-3 374	-850	-2 018	-1 988	-9 705
1982	114	-1 939	-2 318	209	-1 810	-1 908	-7 652
1983	-267	-2 043	-2 206	-294	-2 577	-1 962	-9 349
1984	-237	-2 989	-2 618	-449	-3 199	-2 482	-11 974

Source: Statistics Canada. Science, Technology and Capital Stock Division. *Technology and Trade Statistics: Part 1*. June 1985.

consequence of the relatively low levels of R&D expenditures observed. The report also emphasizes that levels of in-house R&D expenditure as a proportion of sales vary considerably between Canadian-controlled and foreign-controlled high-tech firms. Canadian-controlled firms producing scientific and professional equipment spent approximately 11.5 times more on R&D in 1983 than the foreign-controlled firms. The corresponding rates are 4.1 for business machines, 4.1 for drugs and medicine and 3.6 for aircraft and parts. Coupled with the fact that a significant proportion (45 per cent in 1982) of the assets of the Canadian manufacturing industries are under foreign control, these elements are seen as important in explaining Canada's high-tech trade deficit.

This section examines the data and the methodology underlying the use of the concept of trade in high technology products. To begin with, a major problem is the lack of a common or universal definition to determine which commodities or products qualify as "high-tech." These have been described in U.S. documents as categories that encompass items of high unit value relative to the product field and represent the leading edge of new technology with clear and superior performance characteristics (U.S. International Trade Commission 1982). The OECD in a recent paper indicates five characteristics that can be associated with high-tech products:

- high dependence on a strong technology base and a vigorous R&D effort;
- considerable strategic significance for governments;
- long lead-times from basic research to industrial application, short lead-times in commercialization, and accelerated obsolescence under the competitive pressure of new product and process introductions;
- high risks and large capital investments;
- high degree of international cooperation and competition in R&D production and worldwide marketing (OECD 1985, p. 5).

However, these characteristics do not constitute tangible criteria for classifying commodities and as a result the list of commodities considered to have a high content of advanced technology can vary considerably among the different agencies that use this concept to produce estimates of trade in high-technology products.

Table 6.7 lists some of the different methods of classification which have been used and are still being used in some cases to classify products as high-tech. The DOC1 (U.S. Department of Commerce)

Table 6.7
Methods of Classification of High Technology Products used in the United States and Canada and by the OECD

DOC1	-	Developed by Boretzky: This is an SIC/industry-based definition which uses industry R&D expenditures and employment of scientists and engineers to determine which industries are technologically intensive. High technology industries are generally those which usually spend at least 10% of their gross value added product on R&D and/or at least have 10% of their total employment consisting of scientists, engineers, and technicians. ("Concerns About the Present American Position in International Trade," <i>Technology and International Trade</i> , National Academy of Sciences, Washington, DC, 1971).
NSF	-	Developed by the National Science Foundation: This definition is based on the number of scientists and engineers employed in research and development and company R&D expenditures as a percentage of total sales. R&D intensive goods are those associated with industries having 25 or more scientists and engineers engaged in R&D per 1000 employees and whose R&D funding amounts to at least 3.5% of net sales. The definition uses industry data and is SIC based. (<i>Science Indicators 1982</i> , National Science Foundation).
DOC2	-	Developed by R. Kelly: This definition is based on R&D expenditures relative to shipments. Data used in this definition were product based data. Products having an above average level of R&D intensity were classified as high technology. This definition was originally based on SIC data but an SITC concordance for studying international trade flows was also developed. ("Alternative Measurements of Technology-Intensive Trade," Staff Economic Report, U.S. Dept. of Commerce Office of Economic Research, Sept. 1976, and, "The Impact of Technological Innovation on International Trade Patterns," Staff Economic Report, U.S. Dept. of Commerce, Office of International Economic Research, Dec. 1977).
DOC3	-	Developed by Davis: This definition is also based on R&D expenditures as a percentage of shipments but includes not only the R&D spent directly by the final producer, but also the R&D spent by producers of intermediate products. Products having a significantly greater intensity

Table 6.7 (continued)

of embodied R&D than other products were classified as high-technology. This definition is SIC based. ("Technology Intensity of U.S. Output and Trade," U.S. Dept. of Commerce, International Trade Administration, May 1982).

OECD1 - Products are classified as high-tech on the basis of their R&D intensities, which is computed as OECD-weighted ratios of R&D expenditures and output of each industry. Products are categorized as high, medium or low-R&D intensity depending on whether this ratio is greater than 4, between 1 and 4, or under 1.

OECD2 - This classification is a refined version of OECD1. Only high-tech products are classified. The classification is also based on the R&D intensities of industries but adjustments have been made at the commodity level to exclude specific products of "high-tech" industries which do not qualify as high-tech and to include certain products of "medium-tech" industries which do qualify (see Appendix B).

STD1 - The classification used until recently by the Science, Technology and Capital Stock Division was not based on a set of specific criteria to categorize high-tech products. The classification consisted of a relatively broad-ranging list of products considered technology intensive as suggested by the Industry Branch of MOSST in the 1970s (See Appendix A).

STD2 - The Science, Technology and Capital Stock Divisions has announced at the beginning of 1987 that it is replacing the STD1 classification with the OECD2 classification. This classification is more up-to-date and more likely to provide comparable estimates across countries. The new list has significantly fewer products categorized as high-tech particularly in the non-electrical machinery and chemical groups (see Appendices).

Source for U.S. Classifications: U.S. Dept. of Commerce, *U.S. High Technology Trade and Competitiveness*. Staff Report, February 1985.

and NSF (National Science Foundation) entries are *industry-based definitions*. As pointed out in a 1978 MOSST background paper, they rely on the inter-industry distribution of research and development (R&D) expenditures or other R&D inputs (e.g., the ratio of scientific or skilled personnel) to categorize the technology content of output. According to these definitions, industries corresponding to the chosen criteria are considered "technology-intensive industries," and their total output qualifies as "technology-intensive" without differentiating among the various products. This is clearly inadequate when one considers cases such as that of the petroleum industry, in which high levels of expenditure on R&D should not necessarily result in crude petroleum being classified as a high-tech product.

The U.S. has been able to improve greatly the DOC1 definition by redefining the criteria as being the ratio of R&D expenditure as a percentage of shipments and using *product-based data* at a more disaggregated level than that used with the DOC1. With the use of these data it was possible to derive "product research intensity ratios." This product-oriented measure meant that it was no longer necessary to assume that industry R&D expenditures applied across-the-board to all goods produced by the industry. The use of more disaggregated data on the other hand helps to identify the various levels of research intensity of more products and therefore eliminate certain categories which might otherwise qualify as high-tech only because they are part of a classification containing more research-intensive products. Using the DOC2, it was found that only 44 per cent of the output of the DOC1 technology-intensive industries actually qualified as technology-intensive products between 1968 and 1970. This new definition therefore provides an improvement in measurement.

Unfortunately most countries, including Canada, do not collect R&D expenditure data on a product-related basis. The classification used until recently to classify technology-intensive products in Canada is a modified version of the U.S. DOC2, although a number of additional products have been included, particularly in the machinery category (see list in appendix). This classification, compared with others, is rather broad-ranging and has for some time been considered out-of-date. It has been replaced by a more up-to-date list developed by the OECD.

Although, as Table 6.7 indicates, all basic classification methods put some emphasis on R&D expenditure as a criterion to measure technology, the estimates of balance of trade in high-technology one derives by using various classifications can, in fact, be significantly different. As Table 6.8 demonstrates, the estimates of the high-tech trade deficit for Canada vary considerably, depending on whether the NSF, the DOC2 or the STD1 classification is used to calculate the

Table 6.8
Canadian Balance of Trade in Technology-Intensive Products - Using the DOC2, NSF and STD Definitions
(millions of dollars)

	1968	1969	1970	1971	1972	1973	1974	1975	1976
DOC2 ¹	-950	-1175	-1068	-1154	-1387	-1995	-2709	-2670	-2611
NSF ¹	-2243	-2718	-2551	-2762	-3390	-4394	-5825	-6277	-6461
STD ¹²	-1574	-1894	-1755	-1967	-2369	-3100	-4120	-4433	-4607

Source: 1. MOSST, "Canadian Trade in Technology-Intensive Manufactures 1964-1976," p. 13.
2. Statistics Canada, STD. *Technology and Trade Statistics: Part 1*, 1985, Table 6.

trade balance. For example, the value of the deficit for 1976 ranges from \$2.6 to \$6.5 billion.

The sensitivity of the estimates of the trade balance in high-tech products to the classification methodology is dramatically reflected in the latest data produced by STD. The MOSST 1985 background paper, the ministry's statements and the many articles on the subject in 1986 all focused on the implications of the \$12.0 billion high-tech trade deficit. However, in March 1987, STD announced that it was replacing the classification suggested by MOSST in the 1970s (see STD1 in Table 6.7) for the more up-to-date and narrowly-defined OECD2 classification. The new list is based on estimates of R&D intensities of industries with adjustments made to exclude specific products of high-tech industries and include certain products of medium-tech industries where it is considered warranted. The resulting list categorizes significantly fewer products as high-tech, especially in non-electrical machinery and chemicals groups as compared with the STD1 classification (see Appendices A and B).

Table 6.9 reports the old and new estimates of high-tech trade for 1985. The deficit as calculated under the new classification is less than 50 per cent of the previous estimate of \$12.5 billion. The difference is reflected for the most part in the reduction in import values particularly for non-electrical machinery and electrical products. The exports estimates are affected less because of an additional modification which was required to make the data on imports and exports consistent. Re-exports previously excluded from the value of exports are now included, as they should be since they represent imports that in many cases are processed further and then exported. These re-exports values are in some cases significant. For instance, re-exports in computers and computer parts in 1984 increase the value of total exports in this category by 32 per cent.

Tables 6.10 to 6.12 report the historical series based on the new classification. The new estimates give a clear indication of the most important categories of high-tech trade. Aerospace and non-electrical machinery each account for approximately 20 per cent of total high-tech exports, while telecommunications and computers and related equipment each account for about 16 per cent of exports. On the imports side, computers and related equipment make up 22 per cent and non-electrical machinery 18 per cent of the value of total high-tech imports. The figures also suggest that the value of high-tech exports has grown at a more rapid pace than imports since 1978. The balance of trade estimates indicate that computers and scientific instruments are the major trade categories contributing to the deficit, accounting for 36 and 24 per cent of the total high-tech trade balance respectively.

Table 6.9
Canadian Trade in High Technology Products: Comparison of Exports, Imports and Trade
Balance Estimates Using STD1 and STD2 Classifications¹, 1985
(millions of dollars)

STD1 List STD2 List	Exports		Imports		Balance of Trade	
	STD1	STD2	STD1	STD2	STD1	STD2
Aircraft	2 095		2 763		-668	
Aerospace		2 471		2 680		-209
Office machinery	1 365		4 195		-2 830	
Automatic data processing machines and units		1 877		4 002		-2 155
Electrical products	3 182		6 067		-2 885	
Telecommunications equipment		1 929		1 488		411
Electronic equipment		823		1 541		-718
Electrical machinery		495		1 074		-579
Sub-total		3 247		4 103		-856
Scientific instruments	960	832	3 643	2 218	-2 683	-1 386

Table 6.9 (continued)

STD1 List STD2 List	Exports		Imports		Balance of Trade	
	STD1	STD2	STD1	STD2	STD1	STD2
Other machinery	2 188		5 534		-3 346	
Non-electrical machinery		2 329		3 283		-954
Chemicals	2 588	1 304	2 644	1 613	-56	-309
Total	12 378	12 060	24 846	17 899	-12 468	-5 839

1. This table compares the estimates of trade in high-tech products as previously reported by Statistics Canada (STD1) with the revised estimates recently produced. The large differences in value are the result of replacing the STD1 classification with the OED2 list of high-tech products based on the R&D intensities of industries (see Table 6.7). The new list categorizes significantly fewer products as high-tech particularly in the non-electrical machinery and chemicals groups as compared with the more dated and broad-ranging STD1 classification. The difference is particularly reflected in the reduction in import values. On the exports side, the effect of the change has been lessened by the fact that re-exports which were previously excluded from the estimates are now included. Re-exports are products that are imported into Canada, usually to be processed further, and then exported. This significant modification makes the import and export data consistent.

Source: Statistics Canada, STD, International Trade in "High-Tech" Products, February 1987.

Table 6.10
Total Exports of "High-Tech" Products, Canada, 1978-1985

Product Group	1978	1979	1980	1981	1982	1983	1984	1985
	millions of dollars							
Aerospace	804	1 138	1 556	2 019	2 094	1 817	2 078	2 471
Computers and related equipment	502	734	853	1 034	1 109	1 304	1 765	1 877
Electronic equipment	109	140	217	366	260	338	697	823
Telecommunications equipment	416	609	836	1 054	1 170	1 309	1 867	1 929
Scientific instruments	303	439	536	586	615	749	840	832
Electrical machinery	209	301	317	340	353	305	432	495
Non-electrical machinery	1 211	1 024	644	997	1 261	1 794	2 449	2 329
Chemicals (including drugs)	621	868	952	1 076	861	799	1 093	1 304
TOTAL	4 175	5 253	5 911	7 441	7 723	8 415	11 222	12 059
TOTAL (1981 DOLLARS) ¹	5 873	6 322	6 262	7 441	7 548	8 178	10 478	11 063

Note: Detail may not add due to rounding.

1. The current dollar totals divided by the implicit price index for exports of goods and services.

Source: Statistics Canada, Science, Technology and Capital Stock Division. *International Trade in "High-Tech" Products*. February 1987.

Table 6.11
Total Imports of "High-Tech" Products, Canada, 1978-1985

Product Group	1978	1979	1980	1981	1982	1983	1984	1985
	millions of dollars							
Aerospace	835	1 374	1 808	2 298	1 468	1 759	2 126	2 680
Computers and related equipment	937	1 194	1 743	2 410	2 715	2 957	4 223	4 003
Electronic equipment	257	499	718	840	771	1 060	1 645	1 541
Telecommunications equipment	621	762	840	1 034	955	1 087	1 381	1 488
Scientific instruments	1 048	1 264	1 481	1 732	1 641	1 716	2 134	2 218
Electrical machinery	647	771	751	877	844	847	1 012	1 074
Non-electrical machinery	1 598	1 654	1 581	1 941	1 938	2 298	2 944	3 283
Chemicals (including drugs)	856	1 043	1 099	1 210	1 202	1 406	1 610	1 613
TOTAL	6 797	8 560	10 021	12 341	11 534	13 131	17 073	17 900
TOTAL (1981 DOLLARS) ¹	8 299	9 543	10 482	12 341	11 048	12 470	15 381	15 565

1. The current dollar totals divided by the implicit price index for exports of goods and services.

Source: Statistics Canada, Science, Technology and Capital Stock Division. *International Trade in "High-Tech" Products*. February 1987.

Table 6.12
Balance of Trade in "High-Tech" Products, Canada, 1978-1985

Product Group	1978	1979	1980	1981	1982	1983	1984	1985
	millions of dollars							
Aerospace	-31	-236	-252	-279	626	58	-49	-209
Computers and related equipment	-435	-459	-890	-1 376	-1 607	-1 652	-2 458	-2 126
Electronic equipment	-147	-359	-501	-504	-511	-723	-967	-718
Telecommunications equipment	-204	-152	-4	21	215	222	487	441
Scientific instruments	-745	-825	-944	-1 146	-1 026	-947	-1 294	-1 386
Electrical machinery	-438	-470	-434	-537	-491	-543	-580	-579
Non-electrical machinery	-387	-630	-938	-944	-677	-504	-494	-954
Chemicals (including drugs)	-235	-175	-147	-134	-342	-608	-518	-310
TOTAL	-2 621	-3 306	-4 110	-4 900	-3 811	-4 715	-5 852	-5 841
TOTAL (1981 DOLLARS)	-2 426	-3 221	-4 220	-4 900	-3 506	-4 292	-4 903	-4 502

Source: Statistics Canada, Science, Technology and Capital Stock Division. *International Trade in "High-Tech" Products*. February 1987.

The estimates produced using the STD2 classification therefore convey a very different picture of Canada's balance of trade position in high-tech products. The situation does not appear nearly as severe as was previously thought. Some concern has even been expressed that these new figures may result in a certain complacency—in other words, that officials may decide Canada does not really need to be concerned about its competitiveness in the context of global technological developments. However, even though there is little doubt that the new classification used by STD yields better, more informative estimates, the underlying methodology still consists of assembling in a more or less scientific fashion a list of products categorized as high-tech. The estimates based on such classifications simply convey a measure of the value of trade for these particular commodities. Whether Canada's high-tech trade deficit for 1985 is \$12.5 billion or \$5.8 billion, it remains necessary to differentiate between what these indicators do measure and what they should measure.

c) Issues, Concerns and Proposals for Improved Indicators

The problems and issues which arise in attempts to classify and define commodities as technology intensive are both conceptual and statistical (Statistics Canada, Cat. 88-503E).

- A commodity can be defined as high-tech either on the basis of its intrinsic function or makeup or on the basis of the level of technology of the equipment or process used in its manufacture.
- In terms of data availability, it is difficult to account for the high-tech component of low- or medium-tech products. It is also a problem to isolate specific high-tech commodities from categories which include commodities with a lower-technology content. The more disaggregated the data are, the easier the task of classifying products will be. The estimates produced from these data should also be more informative.
- As the OECD recommended in a recent study, distinguishing between consumer goods and investment goods would probably have a significant impact on the balance of trade of high-tech products. Whereas capital equipment is used to upgrade industrial plants, the import of consumer goods is neutral in this sense.
- Timing becomes a factor when using R&D as a criterion to measure technology intensiveness since expenditures may occur

long before there is an improvement in technology or competitiveness. Similarly, some of today's high technology products are the result of research and development which occurred a number of years ago. This lag factor should probably be taken into consideration when using R&D expenditure as a criterion to classify technology-intensive products or perhaps, as suggested by Palda (1986), the data on net stock of R&D capital are more relevant since expenditures on research and development should not be considered current expenses but rather investments.

- Another problem with using R&D either as a criterion to measure technology intensiveness or directly as an indicator of technology production is the problem of defining what constitutes relevant R&D expenditures. For instance, in Canada, the items which qualify for R&D tax incentives are fairly clearly defined.
- It is also clear that the classification of high technology products would require continuous updating since, given the pace of innovation and the emergence of new technologies and new products, a particular list could quickly be out of date.
- Further qualifications are required as to the characteristics of specific commodities traded and the high-tech designation. For instance, chemicals might be classified as high-tech because of the levels of R&D carried out by the industry. However, they are of very limited specific use and impact beyond that use. Computers, on the other hand, embody high technology, but they also will have a secondary impact through industrial and business applications.

It is clear that further work needs to be carried out to refine the methodology used to evaluate the technology intensiveness of products and to produce indicators of trade in technology. The latest definition developed in the United States, the DOC3 (See Table 6.7) is considerably more sophisticated in that input-output techniques are used to include both the R&D funds directly spent by the final producers, as well as the funds spent by the producers of intermediate inputs used in the final product. This procedure therefore takes into account the indirectly required R&D embodied in the production of capital goods, raw materials and components used as inputs. "Thus, an aircraft gets credit for some of the R&D spent by the industry supplying the avionics, as well as the R&D of the industry supplying the tires" (U.S. Department of Commerce 1985a, p. 32). This approach gives a significantly different picture of the overall technology

intensiveness of products. The other difference in the DOC3 methodology concerns the standard used to differentiate high-tech from lower-tech products. Whereas other measures simply use the average level of R&D as the cut-off point, DOC3 high technology products must embody R&D of a significantly greater intensity than products of lower technology intensiveness. In the classification adopted, the technology intensiveness (TI) of the lowest high technology product is 30 per cent higher than the next product ranked in order of TI.

Unfortunately, Canadian trade estimates based on the DOC3 classification have not been compiled using Canadian data. The original classification is on an SIC (Standard Industrial Classification) basis and although a corresponding classification has been compiled on a commodity basis, (1) the concordance is not direct so that specific weights have to be applied to each commodity category and (2) the commodity classification adopted is the United Nations Standard International Trade Classification, and that classification differs substantially from the Canadian Trade Classification. Producing Canadian estimates based on the DOC3 classification is therefore not as straightforward as might have been the case with the DOC2.

However, it is possible to compare the U.S.-Canadian trade in high-tech products as calculated by the U.S. Department of Commerce using DOC3 and by Statistics Canada using STD2. As Table 6.13 demonstrates, the two sets of statistics appear to be remarkably similar in aggregate, and this can be taken as an indication of the level of improvement in the data brought on by the use of the OECD2 classification in Canada. However, a comparison of more detailed exports data (U.S. 1985a) suggests some discrepancies among product categories, particularly for chemicals, aerospace and non-electrical machinery. At this point it is difficult to say whether these discrepancies are the result of differences in the two product lists or some other factor.

The underlying DOC3 methodology is a definite improvement because it acknowledges the technology embodiment of products, and future work should proceed along this line. We would argue that if R&D is going to be used as the criterion to determine technology intensity, then the measure should include, as Palda recommends, "all industry's direct efforts to enhance its capability for technological change, its own R&D, the access to the results of research of foreign affiliates by foreign-owned subsidiaries within the industry, its skills in inducing government- and university-based research to devote attention to its preoccupations and last but certainly not least, its influence on suppliers' product development activity" (Palda 1986, p. 3). The importance of the access to foreign-based R&D and

Table 6.13
Canadian Trade with the U.S.A.: STD and DOC Lists

Year	STD2	DOC3
millions of U.S. dollars		
Canadian exports/U.S. imports:		
1980	2 784	2 791
1981	3 659	3 627
1982	3 479	3 397
1983	3 878	3 498
1984	5 031	5 120
1985	5 427	5 365
Canadian imports/U.S. exports:		
1980	5 895	5 476
1981	7 162	6 727
1982	6 409	6 148
1983	7 268	6 808
1984	8 943	8 383
1985	8 589	8 134
Canadian balance with the U.S.A.:		
1980	-3 111	-2 685
1981	-3 503	-3 100
1982	-2 930	-2 751
1983	-3 390	-3 310
1984	-3 912	-3 262
1985	-3 162	-2 769

Source: The above table was provided by STD. The estimates are based on the international trade statistics of the U.S. Department of Commerce (United States Trade: Performance in 1985 and Outlook, October 1986) and of Statistics Canada (Science Statistics, "Changes in the Presentation of Some Science and Technology Statistics: 2"). The Canadian trade values have been converted to U.S. dollars using the annual average noon spot rate for Canadian dollars in U.S. funds. This comparison is interesting because about 75% of Canadian trade in "high-tech" products is with the United States.

government-based R&D is particularly significant for Canada given the prevalence of foreign-owned subsidiaries in the conventional high-tech industries and the relatively high percentage of research undertaken by government.

As Palda indicated, the paradox of foreign-owned subsidiaries, including those in R&D-intensive industries, undertaking less R&D than corresponding Canadian-controlled firms is easily explained because of the subsidiary's access to R&D results generated by affiliates abroad. This is partly reflected in the level of technology-related payments to affiliated companies. However, a portion of such transfers probably occur without charge because of the public good nature of technological knowledge within the MNE. These invisible imports are perhaps more important to Canada than most other countries, and they should be taken into account. A MOSST background paper estimated the value of invisible technology imports to be worth \$655 million in 1976.

As far as government-based research is concerned, the argument is that in a country where a significant proportion of research expenditures are allocated to government-performed research, at least a portion of the research will directly benefit specific industries. The classic example is that of agriculture, with government undertaking specific research projects with the goal of improving productivity or products in the sector.

By allocating the percentage of government-based research directly benefiting specific industries, accounting for explicit and implicit benefits from affiliated R&D activity, as well as including the indirect R&D acquired through inputs (as in the DOC3 methodology), all pertinent research inputs would be included directly into the industry measures of technology intensity and indirectly into the indicators of technology embodiment of products. Such an approach may provide an entirely different outlook on the issue of high-tech trade and competitiveness. For instance, Canada's resource-related products may have a high-tech content. Perhaps the Canadian Holstein, a product of biogenetics, is a high-tech product. We should also consider the possibility that some services produced by industries such as banks, which were among the first and most important adopters of computer and telecommunications innovations, should be included as part of our high-tech sector activities (see Economic Council 1987).

Again, the whole issue consists of determining what high-tech indicators are meant to measure. Indicators used to identify industries that may require R&D subsidizing should probably be different than those gauging a nation's competitiveness in the field of technology. In the latter case, relying on direct R&D as the only criterion—based on the assumption that increased R&D leads to

increased technology embodiment which leads to increased exports—is simply too simple. Indications are that the interactions between these factors are much more complex and that there is always a danger of overemphasizing the role of R&D. A broader approach that would capture the overall impact (direct and indirect) of technology would be preferable.

We would suggest that estimates of high-tech trade are only one indicator of a country's competitiveness in this area and that as such it would be much more useful to have an assessment of the actual value of high technology embodied in the traded products and services⁴ than to have the value of trade for a number of products classified as high-tech in a more or less arbitrary fashion. Such an indicator would ideally take account of the high technology inputs, the technology characteristics of the production process, the high-technology services embodied in traded products, as well as the use of skilled labour, and would eliminate other irrelevant factors. With this approach it would be possible to take into account the technology increasingly embodied in the resources-related products and materials that account for our merchandise trade surplus.⁵

Following extensive research in this area, the OECD supports the view that many other factors must be taken into consideration to gain a more global and more accurate assessment of a nation's technology position and the implications thereof.

The methodology of identifying the technology-intensive products will have to be re-examined and widened. The role of technology in trade should be redefined in the light of the three strategies of winning markets: exports, direct investment and transfers of technology. Technology intervenes, however, first of its own accord in the trade in licences, patents and know-how, but also as an explanatory factor in exports and in the benefits connected with direct investment. In exports of comparatively straightforward products, technology plays an indirect part as a production factor in the same way as capital, labour, energy and raw materials. In the case of exports of high-technology products, however, it constitutes, with demand, the decisive explanatory factor (OECD 1983a).

The Balance of Technological Payments

Trade in high technology products is only one of several ways of exploiting and achieving improvements in technology. Licensing, joint ventures, direct investment, research and development, prototype copying and consulting are some of the means by which

proprietary technology flows internationally. In fact, it is possible that these non-trade conduits are rapidly gaining importance and effectiveness. It is necessary, therefore, to consider these factors in analyzing a country's competitive position in technology. The measurement problems associated with these are even more onerous than the ones encountered when estimating high-tech trade.

In terms of statistical concepts, products sales are considered "visible items" in technology trade data, while those items (i.e. flows) measured by payments and receipts for technology-licensing and contracted services—are considered "invisibles". Although the other modes of transfer listed are extremely important in today's world technology flows, by the nature of their forms they are also extremely difficult to monitor (Statistics Canada 1984, p. 9).

The technological balance of payments (TBP) is an indicator of the flow of proprietary technology measured as the value of sales and purchases of technological information and know-how which are recorded in balance of payments statistics. The following chart lists the types of technology transfers either covered or not covered by TBP. Table 6.14 reports data on the technological balance of payments in OECD countries for 1973 and 1983. These data illustrate the dominance of the United States as the "principal centre for the dissemination of technology," and the trend in Japan towards reduced dependence on external sources of technology and a larger role in exporting technology. Canada's importance in these transactions is reflected in the fact that it only accounts for 1.7 per cent of receipts and 5.6 per cent of payments.

Table 6.15 reports the TBP for selected Canadian industries for 1983-1984. Overall net payments equal \$279 million in 1984 with R&D accounting for 31 per cent of the payments and 90 per cent of receipts. The business machines industry accounts for over 36 per cent of total payments. These data have been gathered through the survey of industrial R&D. Non-R&D data are incomplete since only firms conducting and/or purchasing R&D are surveyed. That most of Canada's transfers of technology occur between U.S. parent companies and their Canadian subsidiaries also adds to the problem of measurement.⁶ The modes of intra-firm transfer are likely to be diverse and constantly changing. The reliability of TBP-covered items as accurate indicators of technology transfer transactions will vary greatly since other unrelated factors are likely to influence the level of charges reported. In some cases charges may be used to transfer profits to affiliates while minimizing tax liability. In other

cases, no charge may be involved because other types of longer term benefits are expected.

Modes of Technology Transfer

Technology transfers covered by TBP	Technology transfers not covered by TBP
Licences covering:	Commercial transfers including:
Patents	Commodity trade
Techniques	Direct investment in branch plants
Processes	Joint ventures formed specifically to transfer technology
Formulae	Contractors' sales of turn-key plants
Designs	
Management services	Non-commercial transfers including:
Professional and administrative services	Donation of equipment or materials
Consulting Services	Technical training and assistance
Research and development	Migration of technical personnel
Engineering and scientific services	Internal corporate transfers
	Trade exhibits
	Cross-licensing on a non-cash basis
	Books and journals

Source: Statistics Canada, Science and Technology, Statistics Division. *International Payments and Receipts for Technology*. October 1984.

Nevertheless, the balance of payments (BOP) estimates give some perspective on the relative value of technological transfers. Table 6.16 reports some of the major BOP items for 1984. The business services category includes most of the items relevant to the TBP. As can be seen, the deficit in this category is less than 40 per cent that for trade of high-tech products.

Table 6.17 gives a detailed breakdown of trade in business services for 1984. The figures indicate that about 32 per cent of service receipts and 65 per cent of service payments accrue to foreign-controlled enterprises. Consulting and other professional services form the major service receipt item; it is, in fact, the only item covered by the TBP for which there is a surplus (\$681 million). The largest

Table 6.14
Technological Balance of Payments in OECD Countries
In million US\$ at 1975 prices and as percentage

	1973				1983							
	Receipts	%	Payments	%	Balance	Coverage Ratio	Receipts	%	Payments	%	Payments	Coverage Ratio
United States	3 582.6	(65.7)	456.0	(9.8)	+3 126.0	7.85	4 328.6	(59.4)	132.2	(2.8)	+4 196.4	32.74
Japan	231.2	(4.2)	1 035.7	(22.2)	-804.5	0.22	645.9	(8.9)	748.9	(16.0)	-102.9	0.86
Germany	222.8	(4.1)	618.4	(13.3)	-395.5	0.36	365.1	(5.0)	728.7	(15.6)	-363.6	0.50
France	328.3	(6.0)	476.5	(10.2)	-148.2	0.69	557.7	(7.6)	617.8	(13.2)	-60.2	0.90
United Kingdom	647.2	(11.9)	552.7	(11.9)	+94.5	1.17	650.7	(8.9)	5 140.4	(10.9)	+140.3	1.27
Canada	45.3	(0.8)	188.7	(4.0)	-143.4	0.24	122.1	(1.7)	260.2	(5.6)	-138.1	0.47
Italy	92.7	(1.7)	469.2	10.1)	-376.5	0.20	119.8	(1.6)	485.8	(10.4)	-366.0	0.25
Netherlands ¹	165.7	(3.0)	222.1	(4.8)	-56.4	0.75	209.1	(2.9)	351.3	(7.5)	-142.2	0.60
Sweden	23.9	(0.4)	21.8	(0.5)	+2.0	1.09	58.1	(0.8)	26.6	(0.6)	+31.5	2.19
Austria	10.8	(0.2)	58.4	(1.3)	-47.7	0.18	16.9	(0.2)	88.4	(1.9)	-71.6	0.19
Denmark ²	48.7	(0.9)	39.2	(0.8)	+9.5	1.24	59.9	(0.8)	40.0	(0.9)	+19.9	1.50
Finland	3.7	(0.1)	33.6	(0.7)	-29.9	0.11	28.6	(0.4)	44.6	(1.0)	-16.0	0.64
Portugal	2.7	(0.0)	25.6	(0.5)	-22.7	0.11	4.8	(0.1)	47.7	(1.0)	-42.9	0.10
Spain	51.0	(0.9)	462.2	(9.9)	-411.2	0.11	123.4	(1.7)	596.9	(12.8)	-473.5	0.21
Total	5 456.6	(100.0)	4 660.6	(100.0)	n.c.	1.17	7 290.7	(100.0)	4 679.5	(100.0)	n.c.	n.c.

1. 1982 instead of 1983.

2. 1981 instead of 1983.

n.c.: Non-cumulative

Notes: Excluding Australia because of lack of data.

Source: OECD (1986) *Science and Technology Indicators: R&D, Innovation and Competitiveness*. No. 2. Paris: OECD, p. 55.

Table 6.15
Foreign Payments Made or Received for R&D and Other Technology,
by Selected Canadian Industries, 1983 and 1984

Selected Industries	Year	Payments		Receipts	
		R&D	Other Technology	R&D	Other Technology
		Total	Total	Total	Total
(millions of dollars)					
Transportation equipment	1983	33	2	35	26
	1984	26	4	30	23
Telecommunication equipment	1983	40	8	48	36
	1984	30	10	40	1
Business machines	1983	7	167	174	69
	1984	13	189	202	82
Other electrical and electronic products	1983	3	45	48	26
	1984	3	51	54	22
Chemical products	1983	6	76	82	11
	1984	4	91	95	6
All other manufacturing industries	1983	55	43	98	21
	1984	54	27	81	22
Non-manufacturing industries	1983	32	4	36	28
	1984	41	5	46	34
Total	1983	178	345	523	218
	1984	172	375	547	240

Source: Statistics Canada. *Industrial Research and Development Statistics, 1984*. Catalogue 88-202, July 1986.

Table 6.16
Balance of International Payments, Canada, 1984

Item	Receipts	Payments	Balance
(millions of dollars)			
Merchandise Transactions	112 218	91 493	20 725
Trade in high-tech products	11 222	17 073	-5 851
Service Transactions:	14 189	18 572	-4 384
Travel	4 416	6 542	-2 126
Freight and Shipping	4 332	3 864	468
Government Transactions	544	1 185	-641
Other Services	411	315	96
Business Services	4 486	6 667	-2 181
Investment Income	6 176	19 970	-13 794

Source: Statistics Canada. *Canada's International Trade in Services, 1969-1984*. Cat. 67-510, June 1986.

Table 6.17
Business Services by Category, by Country of Control, 1984

	Enterprises controlled in:			
	Canada	United States	Other	Total
	(millions of dollars)			
<i>Receipts</i>				
Consulting and other professional services	772	118	48	938
Transportation related services	524	36	-	561
Management and administrative services	82	29	9	120
Research and Development	203	82	2	287
Commissions	505	27	28	560
Royalties, patents and trademarks	15	18	7	41
Films and broadcasting	23	4	-	27
Advertising and promotional services	29	1	16	46
Insurance	186	171	94	451
Computer services	93	16	1	110
Equipment rentals	183	6	3	193
Franchises and similar rights	-	-	-	-
Communications	286	18	-	304
Refining and processing services	89	-	-	89
Tooling and other automotive charges	-	493	16	509
Other	72	67	113	251
Total	3 062	1 086	337	4 486
<i>Payments</i>				
Consulting and other professional services	132	59	67	257
Transportation related services	620	18	8	645
Management and administrative services	62	763	47	872
Research and Development	3	487	35	525
Commissions	330	115	21	466

Table 6.17 (continued)

	Enterprises controlled in:			
	Canada	United States	Other	Total
(millions of dollars)				
Royalties, patents and trademarks	59	831	85	975
Films and broadcasting	50	119	-	169
Advertising and promotional services	29	30	5	64
Financial services:				
Insurance	211	282	128	621
Other financial	183	47	-	230
Computer services	24	32	1	57
Equipment rentals	301	118	82	500
Franchises and similar rights	6	3	-	9
Communications	258	5	-	262
Tooling and other automotive charges	-	521	-	521
Other	85	135	272	492
Total	2 353	3 565	751	6 667
Balances	+709	-2 479	-414	-2 181

Source: Statistics Canada. *Canada's International Trade in Services, 1969-1984*. Cat. 67-510, June 1986.

deficit items are royalties (\$934 million) and management and administrative services (\$752 million); 94 per cent of payments of royalties and management service fees are made by foreign-controlled enterprises.

These figures suggest that the TBP values as reported are underestimated, particularly on the payments side, but the discrepancy is impossible to evaluate given the very real but unclear impact of transfer pricing in these particular transactions (i.e. royalties, R&D payments and management fees). What can be said is that in actual transaction values, the transfers of technology occurring through merchandise trade and direct investment are probably much more important for Canada, although invisible technology imports by foreign-controlled subsidiaries are likely also quite significant.

Conclusion

There is no universal definition of what constitutes a high-technology product. The agencies that produce high-tech trade estimates (for example, the U.S. Department of Commerce, OECD, National Science Foundation, and until recently the Canadian Science, Technology and Capital Stock Division) all use a different methodology to identify which products are high-tech. Consequently, the lists used can be substantially different. Because the resulting estimates are sensitive to the classification methodology (the 1985 Canadian deficit of \$12.5 billion calculated by STD decreases to \$5.8 billion using the OECD2 classification), the importance of determining what these indicators are meant to measure is underlined.

Most of the classifications are based on data using expenditures on research and development as a criterion. However, this approach has shortcomings. For instance, the lag time between R&D expenditure and technology applications can be substantial. It also appears that there is some problem in defining what qualify as R&D expenditures especially in a country like Canada, where the government undertakes a substantial portion of total research and where the level of foreign ownership translates into reliance on foreign source R&D. Perhaps we have to question the relevance of R&D as a criterion given the importance in the high-tech sector of multinationals with rationalized international operations. In these circumstances, domestic R&D expenditures may not relate at all to goods produced here. On the other hand, estimates based on domestic R&D fail to acknowledge the access of foreign-owned subsidiaries to R&D performed abroad.

Many other conceptual and statistical considerations are also at issue. For instance, should commodities be defined as high-tech

simply on the basis of their function or make-up or on the basis of the technology associated with the equipment or the production process used to produce them? How do we account for the high-tech component of low- or medium-tech products, or isolate the high-tech commodities classified in a lower-tech commodity category? Should we distinguish between consumer goods and investment goods, and take into consideration the greater technology implications related to the use of certain products (for example, chemicals versus computers)?

We suggest that the methodology could be greatly improved by using input-output analysis techniques to identify the technology-intensiveness of products, taking into account the technology embodied in the inputs and in the services, the capital equipment and skilled labour associated with the production of these products. Perhaps a more useful indicator would be one that equates the value of high-tech trade to the value of embodied technology. Computers will remain high technology products under almost any definition, but with this approach, technology (as a factor of production) would be recognized even in the production and the export of resource-related products. This would enable a more comprehensive assessment of Canada's competitiveness in technology as compared with the present STD estimates.

There are several other modes of transfer of technology besides the trade of high technology products. The technological balance of payments is an attempt to measure the flows of proprietary technology for which there is an associated balance of payments transaction. The items covered include all licence fees, management service fees and other payments and receipts associated with professional, scientific, administrative and consulting services, research and development. However, for many reasons this indicator is only approximate. Again, because of the importance of interaffiliate transactions in this area it must be recognized that the modes of transfer will be diverse (TBP covered and non-covered) and ever changing, depending on the circumstances faced in the individual countries in question. For some, perhaps most, transfers there will be no immediate charge while for others, payments will be incorporated as part of a larger transaction (for example, direct investment). Nevertheless, the transfers of technology which occur through merchandise trade and direct investment are much more significant for a country like Canada than payments for R&D, consulting and management services.

Notes

1. Non-receipt of export documents results in the underestimation of Canadian exports. For instance, the initial estimates of Canadian exports to the United States for 1985 had to be adjusted by \$3.9 billion (see *Toronto Star* June 25, 1986).
2. IRPP interviews with some of the foreign subsidiaries of the U.S. computer manufacturers seem to indicate similar orders of magnitude on both the import side and the export side.
3. STD announced recently that it was adopting a new classification developed by OECD to calculate high-tech trade. This new classification contains fewer products. It is also considered up-to-date and more likely to be used by other countries. Obtaining comparable estimates across countries has been a severe problem. This new classification yields significantly lower estimates of high-tech trade deficit for Canada. These numbers are reported later in this chapter.
4. This concept would be similar to Palda's "output content" technology intensity concept.
5. For example, it has been argued by Nioisi (1985) that one of the factors explaining the success of Canadian MNEs (mostly found in resource-based sectors) seems to be have been their capacity for quickly absorbing innovations originating abroad.
6. For instance, in 1983 approximately 78 per cent of R&D receipts and payments occurred between Canadian companies and foreign affiliates.

Appendix A

Commodities Assigned to the High Technology Category – STD1 Definition

A. Exports

Chemicals:

Chemical elements
Other inorganic chemicals
Synthetic rubber and plastic material
Plastic basic shapes and forms
Medical and pharmaceutical products

Machinery:

Engines and turbines
Electric generators
Other general purpose industrial machinery
Drilling, etc.
Construction
Pulp and paper
Agricultural

Aircraft:

Aircraft and engines
Aircraft engines
Aircraft parts

Electrical Products:

Television, radio
Other telecommunication
Electric lighting

B. Imports

Chemicals:

Inorganic chemicals
Synthetic and reclaimed rubber
Plastic materials, no shaped
Plastic film and sheet
Other plastics, basic shapes and forms
Medical and pharmaceutical products

Machinery:

Engines and turbines, diesel, general purpose
Engines and turbines, general purpose n.e.s.
Electric generators and motors
Compressors, blowers and vacuum pumps
Pumps, except oil well pumps
Other general purpose industrial machinery
Drilling machinery and drill bits
Bulldozing and similar equipment
Front end loaders
Other excavating machinery
Mining, oil and gas machinery
Construction and maintenance machinery
Pulp and paper industries machinery
Agricultural machinery and tractors

Scientific instruments:

Navigation
Other measuring
Medical, ophthalmic and
orthopedic supplies
Photographic

Office Machines**Ordinance****Aircraft:**

Aircraft complete with engines
Aircraft engines and parts
Aircraft parts, except engines

Electrical products:

Telephone and telegraph
equipment
Televisions, radios and
phonographs
Electronic tubes and semi-
conductors
Other telecommunications
equipment
Electric lighting fixtures
Switchgear and protective
equipment
Industrial control equipment
Other electric lighting and
distribution equipment
Auxiliary electric equipment
for engines

Scientific instruments:

Electrical property measuring
instruments
Miscellaneous measuring,
controlling instruments
Medical and related equipment
Navigation equipment
Other measuring, laboratory
equipment
Medical, ophthalmic and
orthopedic supplies
Unexposed photographic film
and plates
Other photographic goods

Office Machines:

Electronic computers
Other office machines

Appendix B

OECD2 List Adopted by STD

Aerospace

Internal combustion engines for aircraft
Jet and gas turbines for aircraft
Aircraft hulls

Automatic data processing machines and units

Computers
Peripheral units

Electronic equipment

Electronic apparatus for medical purposes
X-ray apparatus
Valves, tubes, transistors, semiconductors and other electronic components

Telecommunications equipment

Electrical line telephone and telegraph equipment
Microphones, loudspeakers and amplifiers
Other telecommunications equipment, including satellites

Scientific instruments

Electrical measuring and controlling instruments
Electron and proton accelerators
Binoculars, microscopes and telescopes
Photographic cameras and flashlight apparatus
Cinematographic cameras, projectors, sound recorders and sound reproducers
Other photographic equipment
Medical instruments (except electromedical)
Surveying instruments
Watches and clocks
Photocopying apparatus

Electrical machinery

Electrical power machinery
Apparatus for electrical circuits
Electromagnetic appliances

Electric traffic control equipment
Other electric sound or visual signalling apparatus

Non-electrical machinery

Steam engines and steam turbines
Internal combustion engines (except for aircraft)
Gas turbines
Nuclear reactors
Water turbines and other water engines

Chemicals

Radioactive and associated materials
Synthetic organic dyestuffs and natural indigo
Insecticides, fungicides and disinfectants
Products of polymerization and copolymerization
Vitamins and provitamins
Penicillin, streptomycin and other antibiotics
Vegetable alkaloids, their salts and other derivatives
Hormones
Glycocides, sera, vaccines, etc.

Source: Statistics Canada, Science, Technology and Capital Stock
Division. *International Trade in "High-Tech" Products*.
February 1987.

PART B
TRADITIONAL INDUSTRIAL POLICIES
AND TRADE NEGOTIATIONS

Chapter VII

A High-Tech Strategy

Introduction

Throughout history, governments have established a wide variety of policies and programs to assist economic activities whose growth they wished to encourage. In Part B, we consider the ways in which Canadian governments have applied these traditional industrial policies in the hope of stimulating Canada's high-tech sector. The information technology industry is the focus of our analysis and provides most of our illustrations. We devote separate chapters to tariffs, subsidies, government procurement, regulations, and the protection of intellectual property. The policies differ considerably in many important respects, so we feel that each must be examined separately. Although the policies are distinct in mechanics and impact, nevertheless, from the perspective of the high-tech sector, they are all motivated by the government's desire to encourage the expansion of Canadian firms. We feel that this common motivation justifies our reference to the policies as a high-tech strategy, even though they have not been developed in unison as a coherent, integrated, national program.

Seeing the policies as a unit is important because a government can substitute one type of assistance or protection for another. Examining each as individual components of a high-tech strategy may lead one to recommend a shift from one policy to another. Our studies have led us to advocate such a shift, and in Part C we emphasize

education and research as the most appropriate focus for contemporary government assistance.

Being able to substitute one policy for another within a high-tech strategy is particularly important in the context of trade negotiations. New international agreements will seek to limit the freedom of governments to implement some policies. The various types of government intervention each serve to alter the patterns of production and consumption that would develop in a free market. In this process, foreign firms may believe that their commercial opportunities are being restricted, and that they are being subjected to unfair competition. Preferential treatment for domestic firms means that foreign firms encounter barriers to trade. It also means that foreign firms encounter a price structure that is replete with artificial price distortions caused by government policies. To the degree that new international agreements do limit the freedom of governments to implement some policies, Canada's high-tech strategy may have to be altered. A central purpose of Part B is to consider the ways in which trade negotiations are likely to have an impact on Canada's high-tech strategy, requiring such alteration. Our emphasis on education and research in Part C is best appreciated against this background of shifts in traditional policies that may be required as a result of new international agreements.

We conclude that government policies aimed at education and research are today the most effective mechanism through which Canadian governments can enhance Canada's international competitiveness. We are confident that by using appropriate policies, Canadian governments can engineer a comparative advantage in high technology. Furthermore, such policies can be seen as the best form of adjustment assistance. Retraining of workers displaced by changing trade patterns will be increasingly important in order for them to obtain new jobs, and trained employees will assist corporations to adopt new production technology. Together, these perspectives emphasize a creative adjustment process resulting in dynamic progress and increased international competitiveness.

The Impact of Trade Negotiations

For Canada's information technology sector, international trade negotiations will be very important for the foreseeable future. While the Tokyo round of the General Agreement on Tariffs and Trade (GATT) negotiations reduced tariff levels worldwide, tariffs still exist for many products, and for some product categories they remain at levels high enough to affect trade patterns and corporate profits. Meanwhile, recent years have seen a proliferation of other government programs and policies that are changing corporate

production costs and export opportunities. Often these are referred to as non-tariff barriers (NTBs).

Financial assistance through a wide array of subsidy programs and special tax concessions can influence investment and production decisions. They can reduce corporate costs below free market levels in a manner that foreign competitors see as unfair. Special government programs to provide export financing—often at interest rates below market levels—can obviously have a direct impact on international competitiveness.

Governments themselves have become major purchasers of goods and services. In most countries, government procurement policies have been formulated and operated to favour domestic producers. Defence purchases are particularly important in this regard, and here domestic sourcing is an especially sensitive issue.

A wide array of legislation, regulations, and guidelines seek to modify corporate behaviour in the public interest. Many of these policies, particularly those concerning foreign ownership, can affect opportunities to export and import.

The extent and nature of patent and copyright protection have become increasingly important in determining trade patterns. "Intellectual property" has become a larger segment of trade in services. "Counterfeiting" and widespread reproduction of goods and services, usually in less developed countries with lower wages, are eating into the markets of North American producers.

The most recent round of GATT negotiations included discussions about restraining the use of some of these non-tariff barriers, and many GATT members, including all industrialized countries, have signed supplementary GATT codes to limit their use. However, in practice, these agreements have been difficult to enforce. Within federal nations, the subordinate governments—such as Canadian provinces and U.S. states—are not bound automatically by these agreements. Also, many observers fear that governments are continuing to erect additional NTBs of new and different kinds, often as elements of high-tech strategies. The prospective new round of multilateral negotiations under GATT will provide an opportunity to strengthen, elaborate and extend the GATT rules as they affect trade in high-tech goods and services. Even if NTBs cannot be eliminated, such negotiations may at least restrain their proliferation.

GATT negotiations have traditionally dealt with physical products (goods). However, recent years have seen a rapid growth of services as a percentage of GNP. Trade in services is covered by GATT rules only to a limited extent, and many observers believe that new rules are needed to liberalize trade in services and to prevent the introduction of new trade barriers.

Services are particularly vulnerable to NTBs. Many services are thought to be intimately related to the protection of national culture and sovereignty, and so have been subjected to foreign ownership regulations and other controls. With regard to services, the issues of "right of establishment" and "national treatment" have special importance.

NTBs that restrict trade in services can also be devised so as to be hidden. Domestic preferences can be informal or vague practices. Other nations have difficulty in proving their existence so they can demand their removal. Enforcement of negotiated agreements is a particular problem, and international rules will require a high degree of transparency in domestic regulations.

For Canada, trade relations with the United States are of paramount importance, since the U.S. is by far our largest export market and our largest source of imports. Many U.S. corporations have complained to their congressmen and senators that Canadian producers are able to underprice them because of government financial assistance. Because of this, attempts have been made to impose special U.S. countervailing duties on some Canadian exports, such as fish, lumber, and hogs.

Many other Canadian exports are threatened or are perceived to be threatened by U.S. "contingent protection" systems. For example, U.S. steel producers have lobbied successfully for Voluntary Export Restraint agreements, limiting the amount of some types of steel imports from individual foreign suppliers. So far, Canada has resisted entering into such an arrangement to limit shipments to the United States, but U.S. producers are trying to impose limits on imports of Canadian steel as well.

In the recent Canada-U.S. trade negotiations, the Canadian negotiators sought arrangements that would protect Canadian producers from harassment under the U.S. countervailing duty and other "contingent protection" systems. However, the United States has been unwilling to grant any kind of blanket exemption in this regard. The issues here are of the greatest importance for Canada.

Many of the government programs and policies that affect production costs and investment decisions—and, consequently, trade patterns—have become permanent features of modern societies. These programs or policies will inevitably limit the concept of "free trade" in the sectors concerned.

What modifications could enhance the fairness of international competition without harming essential national objectives such as cultural identity and commercial sovereignty, income redistribution and social security, and programs to stimulate technological progress? The answers to this question vary among nations. And the answers will change as societies evaluate the success and the shortcomings of

these government activities. Consequently, trade negotiations addressing NTBs will be with us for the foreseeable future.

For corporations, this means that continual input into the negotiation process will be extremely important. International sales will continue to be affected by these NTBs and, from time to time, by the retaliations of various governments. Being aware of possible developments in this area will minimize unpleasant surprises. Being able to influence favourable outcomes will offer financial rewards.

It should also be noted that governments today are actively seeking information from corporations, directly and through their trade associations, as to the likely impact of alternative domestic policies and alternative trade agreements. It would be unfortunate, to say the least, if today's corporations were to reject a role in this process.

As part of the Canada-U.S. negotiation process, the Canadian government created new corporate advisory groups. The perspective presented here suggests the need for a permanent consultative structure to deal with the continuing nature of Canada's future trade negotiations and processes to resolve disputes.

The Impact of a Changing World Economy

International trade and investment are causing the economies of all countries to become more closely integrated. To an ever-increasing degree, we are fast becoming one immense international marketplace: a new world economy.

Important changes in technology underlie this increasing integration. Since the mid-1960s, for example, air cargo transportation has come to play a major role in international trade. In 1965 only eight per cent of U.S. exports were carried by air. In 1984, this had risen to 24 per cent. Dramatic new improvements are expected in aircraft technology, so we may expect international trade to become even cheaper and quicker.

Phenomenal innovations are occurring regularly in the technology of transferring and analyzing information. In each of the two decades since the mid-1960s, the costs of computation declined 90 per cent. Over the next 20 years, we can reasonably expect a continuation of this trend. Tomorrow's computation costs will be a tiny portion of today's costs. These technological changes facilitate all trade, but in particular they underlie the recent rapid growth of trade in services. Increasingly this growth of trade in services will present new challenges and new opportunities.

Consumers around the world are coming to share the same preferences. Producers are coming to share the same knowledge of production technology. We now live in a world that is a far more

homogeneous marketplace than it used to be. Transportation costs have plummeted and the speed of transportation has increased. Satellite technology has combined with innovations in televisions and VCRs to bring one country's events into the living rooms of all other countries. Information and services can be exchanged rapidly, sometimes instantaneously. Specialization has intensified, within both companies and countries.

The implications of this trend towards one integrated marketplace are likely to be of major significance for each of us in our daily work and for each of our governments as policy makers. When businesses and governments make decisions they must consider the impact of their decisions on other nations. To an increasing extent, businesses and governments have a responsibility to cooperate with people in other countries, as well as to compete. For example, in the U.S.-Canada negotiations over acid rain, it became clear that the actions of one corporation in one country can affect all of us. Environmental pollution has become an international issue. And control of environmental pollution will require enormous investments in research to develop new production technologies. Here we clearly see the advantages of technological cooperation.

Several other issues present more difficult choices between cooperation and protectionism. Consider the impact of foreign technological progress on trade patterns and Canadian manufacturing. When Japan develops a new product or a less expensive production technique, Canadian manufacturers can be exposed abruptly to obsolescence and workers can suddenly face unemployment. In many of the less developed countries (LDCs), the adoption of mass production technology is being combined with wages as low as one-fifth of Canadian wage levels. The result—whether in shoes, textiles, and automobiles, or in certain products of the information technology sector—can throw thousands of Canadians out of work.

Should foreign nations be free to compete in our marketplace with their new technology? Or should they cooperate with us in smoothing our transition process? Clearly we shall be compelled to switch out of our traditional manufacturing and into new products and new processes. But should international agreements put limits on our imports in order for our corporations and employees to have time to adjust? Do Canadians need import quotas? Should our trading partners commit themselves to "Voluntary Export Restraints"? What is the appropriate balance between cooperation and competition?

Many Canadians see the rising flood of cheap imports from less developed countries (LDCs) as the key mechanism whereby the LDCs can achieve economic growth. From this perspective, the obligation is on us to speed up our transition into new products and new processes.

The obligation is on us to expand our government programs of domestic adjustment assistance.

Canadians who are thrown out of work by the technological progress in LDCs must be given special retraining for more highly-skilled jobs, grants to pay for the costs of relocating homes and families, and early retirement pensions for those too old to make retraining feasible. Most important, perhaps, is our responsibility to stimulate the adoption of the latest advances in technology within Canada so that new job opportunities will be available. From this perspective, international cooperation involves positive commitment on our part to shift our industrial structure, rather than relying on a negative defence of restricting our imports.

Economists have long debated the appropriate role of government in stimulating new technology. A corporation will not be able to capture all the benefits from an invention. Others will copy the invention if it is successful, so a corporation will not invest as heavily in R&D as the public interest would require. Over the years, governments have developed patent and copyright systems to protect the inventor, ensuring a more complete financial return, and so hoping to encourage the R&D process. Various international agreements have been signed to extend such protection worldwide.

These international agreements, however, seem to be losing their effectiveness. Counterfeit goods have become commonplace, based often on cheap offshore production. Some modern services, such as computer software, can be readily copied with enough variation to evade patent and copyright provisions. Modern technology has enabled the rapid creation of substitute products and processes. Meanwhile, some nations see an advantage to their own industries if they refuse to honour foreign patents and copyrights.

Faced with this situation, the United States is pushing for greater cooperation in the international protection of new technology. Over the next few years, we will witness a significant debate about the appropriate balance between rigidly enforced cooperation in patent and copyright protection and unrestrained free competition.

Computer software provides a particularly interesting example of this issue. At present, Canadian laws do not explicitly include software as something protected by copyright. For several years, our courts have been dealing with cases where software piracy has been involved, and generally judges have supported the claims of the innovators to exclusive ownership. However, this court process involves substantial costs. Even worse are the long time lags involved. Piracy may continue for months or years before a case is dealt with. International cooperation and our own self-interest both seem to require amendment to our Canadian laws.

A May 1986 court decision is regarded by some observers as a major step forward in computer software protection. This case involved a lawsuit by Apple Computer Inc. against a large number of defendants. Apple claimed that the defendants were assembling and selling computers that were almost identical to the Apple II.

A central issue was whether the software should be viewed as "literary works" owned by Apple Computer Inc., or whether the encoding of software on silicon chips should be viewed simply as hardware. Madame Justice Barbara Reed ruled in favour of Apple Computer Inc. Judicial decisions like this may deter future copying of software without the originator's permission, quite apart from changes in the law. Nevertheless, some still feel that clarification of the legal statutes would be appropriate.

The difficulties of protecting new technology from copying by competitors has led many economists to advocate public subsidies as an alternative mechanism for stimulating R&D. Since the public as a whole will benefit from technological advances, the public should pay part of the R&D costs.

Throughout economic activities, the adoption of new technology today is closely linked with investment in new machinery and equipment. Modern technology is often embodied in capital goods that must be acquired in order to use that technology. In order to stimulate technological progress and create new jobs, governments around the world have put in place a wide array of programs that give financial assistance to private companies for R&D investment.

However, this has also resulted in conflicts among nations, as each tries to outdo the others in this competition for new investment and new technology. Furthermore, these subsidies can reduce the cost of a corporation, enabling it to underprice its foreign competitors in a way that could be considered unfair competition. This in turn can lead to demands for countervailing duties or special import quotas. In this subsidy question as well, the U.S. government hopes that multilateral negotiations can shift the balance towards more cooperation and less competition. One might even speculate that in an ideal world, all governments would contribute jointly to finance the technological advances from which all may gain. Perhaps for some of the largest research projects, such as nuclear fusion, this dream of international research cooperation may some day become a reality.

In some of these difficult areas—where an appropriate balance must be struck between international cooperation and international competition—it is clear that Canada-U.S. bilateral negotiations will be limited. Relatively little can be achieved by two countries acting alone. These issues involve the relationships among a large number of countries and a new round of multilateral negotiations is the major forum in which progress may be achieved.

It is true that Canada and the United States can advance by themselves in solving some problems, such as North American acid rain. Yet even many environmental pollution problems must be dealt with on a worldwide basis. Furthermore, the technological advances that create cheaper imports can occur in any foreign country and flood markets worldwide. Responses such as the Multifibre Agreement have sometimes been multilateral. North American inventions can be copied anywhere, and any foreign government can attempt to outbid us in the competition for new investment and R&D. The dilemma of technological cooperation and technological competition is a worldwide dilemma and requires a worldwide approach to its solution.

Conclusion

The following chapters examine alternative government policies that may foster the creation and diffusion of new technology. Throughout the world, the creation and diffusion of new technology is perceived as the foundation for future economic growth and prosperity. Less developed nations are quickly adopting technologies that were created in the advanced economies of Western Europe and North America. This technology transfer has altered traditional patterns of comparative advantage and international trade. Meanwhile, the advanced economies have become increasingly concerned about their ability to innovate. This race for more efficient technology has become a major determinant of international competitiveness. As participants in this race, individuals and corporations now look to their governments for public policies to help them to win. For many societies, the ability of government to engineer a comparative advantage is of paramount concern.

Fear exists that Canada is losing this international race for new technology. Not surprisingly, this perception has led to criticism of government policies. Part B examines the traditional policies of tariffs, subsidies, government procurement, regulation, and the protection of intellectual property. A unifying theme of Part B is that these traditional industrial policies have become the focus of new international negotiations that seek to create freer trade. The ability of each nation to rely on these policies as instruments of its high-tech strategy is being curtailed by new international agreements. The nature and extent of such curtailment will likely differ among policies. From this perspective, the following chapters consider the relationships between a high-tech strategy and international trade agreements.

Chapter VIII

Tariffs

Introduction

Throughout Canadian history, tariffs have been regarded as a key element of industrial strategy. Therefore, in considering ways for governments to stimulate the information technology sector, tariffs deserve special consideration. This chapter presents a brief history of GATT tariff negotiations, indicating the current tariff levels. For computer manufacturers, current Canadian and U.S. rates of 3.9 per cent for hardware and nil for software are not a major determinant of trade patterns. Nevertheless, since most Canadian purchases are imported, tariff reduction would directly reduce selling prices. This could increase sales, accelerating the Canadian adoption of technological advances. A lower U.S. tariff would also directly affect the profitability of Canadian computer firms since most of their production now goes to the U.S. market. Telecommunications and factory equipment generally face higher tariffs, so new tariff agreements could require substantial adjustment by manufacturers. Tariff reductions would facilitate international specialization and global mandates in telecommunications and factory equipment.

GATT Tariff Negotiations

The General Agreement on Tariffs and Trade (GATT) came into effect in 1948, and since then has formed the framework for international

trade negotiations. Most countries are members of GATT, and even many non-members adhere to some of its agreements. In his book, *Canada, the GATT, and the International Trade System*, Frank Stone describes five distinct functions of the organization. GATT provides:

- a permanent framework for continuing international consultations on world-trade-policy developments and problems, and the evolving trade policies and practices of individual member countries.
- a common set of rules for the conduct of trade, which constrain and discipline the trade policies and practices of individual member countries. The several supplementary codes and agreements that have been adopted within the GATT framework provide further rules and disciplines for those countries that have signed them.
- a framework for the liberalization of world trade, through negotiations aimed at lowering the tariffs of member countries and exchanging commitments not to increase these tariffs, as well as by the application of rules that prohibit or control the use of non-tariff measures.
- facilities and agreed procedures for the resolution of trade disputes among its member countries.
- facilities for collecting and disseminating information about developments in world trade and the trade policies and measures of member countries, as well as for independent research and analysis of trade policy issues (Stone 1984, p. 23-24).

Stone also discusses the seven post-1945 rounds of trade negotiations, noting that "the first 1947 round in Geneva, the Kennedy round, and the Tokyo round were by far the most important. Tariff cutting as a result of the other GATT rounds was more limited" (p. 57). The seven rounds of tariff negotiations were as follows:

- 1947 - Geneva (parallel with the negotiation of the General Agreement)
- 1949 - Annecy, France
- 1950-1951 - Torquay, England
- 1955-1956 - Geneva
- 1961-1962 - The "Dillon Round" in Geneva

- 1964-1967 - The "Kennedy Round" in Geneva
- 1973-1979 - The "Tokyo Round" of Multilateral Trade Negotiations (MTN), in Geneva (Stone 1984, p. 57).

In each of those rounds, most of the negotiating agenda concerned the reduction of tariff rates, and the Tokyo round did establish a timetable for future tariff cuts. Recent years, however, have seen a growth of other barriers or interferences with trade, including subsidies, countervailing duties, product standards, customs valuation, government procurement, and import-licensing procedures. In view of this, the Tokyo round also attempted to create fair and uniform rules for these non-tariff barriers (NTBs).

The Tokyo round tariff reductions were phased in gradually over the 1979-1987 period with the depth of cut varying from one country to another, depending on the height of the 1979 tariff levels. The average tariff cuts ranged from 28 per cent for Sweden to 49 per cent for Japan. These cuts still leave some differences in tariff rates among the signatories, but overall international tariff barriers have been lowered.

For raw materials, the post-1987 average tariffs will range from 0 in Sweden to 0.5 per cent in Canada and Japan. For semi-manufactured products, the post-1987 average tariffs will range from 3.3 per cent in Sweden to 8.3 per cent in Canada. For finished manufactured products, the post-1987 tariffs will range from 4.9 per cent in Sweden to 8.3 per cent in Canada. These figures are found in Table 8.1, which presents percentage depth of tariff cut and average post-1987 tariffs for several of the signatories.

Table 8.1 indicates that Canada will still have significant tariffs for many products, even after the Tokyo round tariff cuts are fully implemented. In particular, Canadian tariffs for semi-manufactured and finished manufactured products will be substantial on average. For some products, Canadian tariffs will be much higher than the average level of 8.3 per cent.

Table 8.2 provides a more detailed breakdown of the Canadian tariff rates in 1976 and the post-1987 levels. For some product categories the post-1987 rates will be extremely high: 19.2 per cent for tobacco, 18.7 per cent for apparel and textile products, and 12.1 per cent for rubber and plastics.

It is extremely important to realize that the tariff rates in Tables 8.1 and 8.2 are all average rates for groups of products. Within many product groups, tariff rates vary widely. From the perspective of each corporation, the important point is the tariff level for the specific products that the particular corporation manufactures or imports.

Table 8.1
Post-MTN Average Tariffs on Industrial Products^a
 (per cent)

Country	Depth of Cut ^b	Raw Materials	Semi-Manufacturers	Finished Manufacturers
U.S.A.	31	0.2	3.0	5.7
Canada	38	0.5	8.3	8.3
Japan	49	0.5	4.6	6.0
EEC	29	0.2	4.2	6.9
Sweden	28	0.0	3.3	4.9

a. Source: GATT, Director-General, The Tokyo Round of Multilateral Trade Negotiations, Supplementary Report (January 1980).

b. Depth of cut is for all industrial products; depth of cut and average post-MTN rates are weighted on the basis of actual customs collections.

Source: Stone (1984, p. 182).

For the high-tech sector, including computers and telecommunications, products manufactured and imported would fall mainly into the Table 8.2 categories of electrical machinery or scientific and precision instruments with average post-1987 tariff rates of 6.8 per cent or 5.1 per cent respectively. However, the tariff rate structure is far more complex than suggested by Tables 8.1 and 8.2. On June 2, 1986, the government announced that effective June 6, 1986, the Computer Parts and Semiconductors Duty Reduction Order (PC 1986-124, January 16, 1986) would be cancelled and that Bill C-III covering the 1986 budget tariff amendments would be amended by striking out tariff item 41417-3 which provided for the duty-free entry of computer parts. As a result, computer parts are now dutiable under tariff item 41417-1 at 3.9 per cent when entered under the Most-Favoured-

Table 8.2
Canadian Tariff Protection
(nominal tariff rates by commodity)

	1976	1987 ^a
		(projected)
Agriculture		
Meats and dairy products	4.8	4.1
Cereals	2.6	2.5
Other agricultural products ^b	3.2	2.6
Forestry and fisheries	.5	2.5
Mining		
Coal	0.0	0.0
Oil, natural gas	0.0	0.0
Metallic, non-metallic, and other	0.6	0.4
Manufacturing		
Non-durable goods: tea, sugar, coffee, spices, cocoa	8.4	7.8
Alcoholic drinks	6.7	3.9
Other foods ^c	5.0	3.7
Tobacco	20.5	19.2
Apparel and textile products	20.6	18.7
Paper, printing publishing	9.5	4.9
Pharmaceuticals and toiletries	10.3	8.7
Other chemical and other allied products	7.9	6.9
Petroleum and coal products	8.8	6.7
Rubber and plastics	15.4	12.1
Durable Goods		
Lumber, wood, and furniture	10.4	7.2
Primary and fabricated metals, stone, glass	10.9	7.2
Machinery except electrical	6.5	4.6
Electrical machinery	13.9	6.8
Transport vehicles	10.0	6.6
Scientific and precision instruments	8.8	5.1
Miscellaneous manufacturing	7.6	5.6
Average tariff across all imports	9.5	6.8
Average tariff across imports from the United States	8.5	6.1

a. This corresponds to the end of the Tokyo round implementation period.

b. Other agricultural products include fruits, vegetables, oil seeds, nuts, animal feed, crude animal and vegetable materials, silk, wool, cotton, jute and vegetable fibres.

c. Other foods include animal and vegetable oils and fats, miscellaneous food, prepared fruits and vegetables, prepared cereals, beverages, prepared meat and fish.

Source: J. Whalley, *Canadian Trade Policies and the World Economy* (1986), p. 20, based on an analysis of GATT data undertaken by the Special Trade Representative, U.S. government.

Nation Tariff. Some parts will continue to enter free of duty when classified under tariff item 41417-2.

An additional element of complexity is the fact that—for any particular product—Canadian tariff rates vary from one country to another. Apart from the highest rates of the General Tariff, there are four distinct tariff categories: British Preferential Tariff, Most Favoured-Nation Tariff, General Preferential Tariff, U.K. and Ireland Tariff.

Implications of Canada-U.S. Tariff Reduction for the Information Technology Industry

For computer manufacturers, current Canadian and U.S. rates of 3.9 per cent for hardware and nil for software are not a major determinant of trade patterns. Yet, even for computer manufacturers, the issue of tariffs cannot be entirely ignored.

For most business equipment, a Canada-U.S. freer trade agreement would probably reduce prices for Canadian customers by as much as the amount of the tariff reduction. This would occur because today Canadian tariffs are usually added on to the U.S. selling prices, and are paid by the customers. This could increase sales in Canada, speeding Canadian adoption of technological advances. Tariff reductions would probably not hurt any computer manufacturers since at their current low levels it appears that they are not acting to protect any Canadian manufacturers from foreign competition.

A Canada-U.S. freer trade agreement could help computer manufacturers to the degree that they wish to export to the United States. For multinationals, a lower U.S. tariff would enable the Canadian subsidiary to compete at lower cost—against subsidiaries in other countries—in the pursuit of global product mandates. A reduction in the U.S. tariff could increase Canadian profitability. Export prices are determined in the U.S. marketplace, so Canadian exporters might be able to raise their prices by a portion of the U.S. tariff reduction.

Telecommunications and factory equipment generally face higher tariffs (approximately 17.5 per cent for telecommunications and a wide range for factory equipment). Tariff reductions could speed up the shift to these products by computer manufacturers who are multinationals, since tariff reductions would facilitate international specialization and global product mandates in these areas. For manufacturers of telecommunications and factory equipment, the current high levels of tariffs have probably been a major determinant of trade and investment patterns. Hence tariff cuts could require substantial adjustment by the manufacturers.

The Canadian government does allow manufacturers to import parts free of duty. However, the regulations surrounding duty-free parts imports are burdensome, and it would be helpful if these could be modified. In particular, regulations do not permit the sale of these to independent repair staff, requiring that the importer use them directly. This acts as a disincentive to doing repair work in Canada. Relaxation of this requirement would be desirable from the perspective of both the importers and the independent repair firms.

Import shipments are regularly delayed at the border for customs inspection. These delays are particularly troublesome when customers need immediate service. It is hoped that a "New Customs Commercial System" may provide for immediate customs clearance, leaving the paperwork and tariff remittances as a responsibility of the importer. This type of automated entry system would be appreciated by both importers and their customers.

The division of products into categories for tariff purposes is somewhat unclear and arbitrary. Computer parts face a tariff of zero while assemblies face a tariff of 3.9 per cent. Hence as one element of a computer system, a printer has a duty of 3.9 per cent, but it could be imported separately without paying duty. A telecommunications system faces a tariff of 17.5 per cent, but some of its components could be imported separately either as computers at 3.9 per cent or as parts at 0 per cent. It appears that some CAD-CAM systems can be imported free of duty if they result in productivity increases. This leads to distortions in import orders, as the importers arrange their shipments so as to minimize duties payable. This lack of consistent and uniform treatment may result in importers being dealt with unequally.

For importers, the various nuisance elements described above appear to be as significant as the need to pay tariffs. A freer trade agreement that eliminated tariffs would provide the substantial benefit of eliminating these nuisance elements, thereby reducing costs and enhancing efficiency.

Duty Remission Arrangements

In some situations, the Canadian government has suspended its tariffs on imports. These duty-free situations are determined on an *ad hoc* basis, involving separate negotiations with each importing company. To describe the criteria for duty remission arrangements, it may be appropriate to quote a 1983 publication of the Department of External Affairs:

In addition to those resulting from multilateral trade negotiations, there are tariff changes being made on an on-

going basis, usually as a result of representations by the private sector. Such changes are made in the context of budgets or by Order-in-Council depending on the circumstances. Changes of the latter type include temporary tariff items providing for a reduced or nil rate of duty on raw materials, semi-finished goods and components imported for further manufacturing in Canada, and duty remissions pursuant to the Financial Administration Act. In the course of the last few years there has been a growing demand for such schemes, especially from Canadian subsidiaries of foreign multinationals who find Canadian and foreign tariffs to be an impediment to the granting of "product mandates" to their Canadian plants. Part of the remission provided by such schemes is typically used to pay the U.S. tariff on exports of the "mandated" product to that country (Canada, Department of External Affairs 1983, p.130).

Since these duty remission arrangements are negotiated separately with each company, confidentiality is involved. This confidentiality prevents us from presenting clear statements concerning particular industrial sectors.

Conclusion

The continuing reduction of tariffs as a result of new international agreements will diminish the role that tariffs can play within Canada's high-tech strategy. In any case, a strong argument can be made that the traditional reliance on tariffs to protect domestic producers is no longer in the best interests of Canada's information technology sector. It is also clear that Canada's ability to benefit from future international agreements to reduce tariffs will depend upon the ability of Canadians to alter their production processes. This explains our emphasis in Part C of this book on the research and education policies that can enable Canadians to adjust successfully to the lower tariffs of the new world economy.

Chapter IX

Subsidies

Introduction

Throughout the world, governments use public funds to assist private enterprises. A wide variety of programs are used to allocate these public funds. The programs differ in regard to their objectives and their allocation criteria, and many people believe that such subsidy instruments should be used as a high-tech policy.

Subsidies can alter the price ratios that would result in a free competitive marketplace, so the recipients of subsidies may offer their goods and services for sale at lower prices than they would receive in the absence of subsidies. Foreign-based corporations often consider these lower prices as unfair competition. Hence international trade negotiations have come to focus on these subsidy programs as a trade distortion that should be limited by formal international agreements. The last General Agreement on Tariffs and Trade (GATT) round of negotiations resulted in subsidy codes for particular types of financial assistance. U.S.-Canada negotiations have also dealt with this subject. Meanwhile, the U.S. has taken a firm position that it should impose special countervailing duties if any of its corporations are being hurt by foreign subsidies. Therefore, the role of subsidies as a high-tech policy must be considered in the context of international trade negotiations.

Canadian subsidies that are aimed directly at education and research are not dealt with extensively here, but rather are treated separately in Part C. Education and research subsidies have not yet

become the focus of international agreements. Other countries have not sought to limit their use, because usually education and research subsidies do not directly alter market prices.

Canadian Subsidy Programs

In a volume entitled *Intervention and Efficiency*, the Economic Council of Canada (ECC) has constructed a number of tables which list the major government agencies and programs that provided loans, investments, and loan guarantees in 1980.

A number of programs have been created to encourage R&D and the adoption of new technology. To the extent that they provide financial assistance, these programs could be regarded as subsidies. They include the Enterprise Development Program (EDP), the Industrial Research Assistance Program (IRAP), the Program for Industry/Laboratory Projects (PILP), and the Defence Industry Productivity Program (DIPP), all of which are described in detail in Chapter XV. It could also be argued that tax concessions aimed at providing financial incentives for research and development and particular investment patterns (such as the Quebec Stock Savings Plan) represent a form of subsidy.

The Canadian Export Development Corporation is particularly important in international negotiations because of the direct impact it can have on trade patterns. Private corporations in other countries may feel that Canadian firms enjoy an unfair competitive advantage because they receive subsidized export loans at interest rates below market levels, together with government guarantees of commercial bank loans, and insurance to cover the risk of foreign buyers defaulting on their payments.

Canada and its provinces have created a large number of Crown corporations, many of which produce and sell significant quantities of goods that are produced by private firms in other countries. Generally, such government operations do not base their prices on the same market criteria followed by private firms, nor do they always pay the same levels of corporate income taxes as private firms. A market rate of return on capital invested is usually not of the same concern in government as in private business operations. Government provision of capital to such firms at less than market rates, and government payments to cover operating losses, can provide significant subsidies for the products concerned, and these subsidies may distort trade patterns. The energy sector provides examples of this, where Canadian government-owned hydro and oil companies may compete with private U.S. corporations. Before privatization, the Ontario government's Urban Transportation Development Corporation competed across Canada and in other countries to sell rail

passenger vehicles, subway cars, and integrated urban transit systems.

Government marketing agencies may also subsidize private domestic producers in a manner that affects international trade. This has been the case with agricultural marketing agencies; the common agricultural policy (CAP) of the European Economic Community (EEC) has had serious effects on world trade recently, for example, involving disputes with the United States over exports to Egypt and China. For its own part, of course, the U.S. government's price support programs have a major effect on the prices and quantities of traded agricultural products.

It is important to recognize the large and growing role of provincial governments in the provision of subsidies. By drawing investment to one province instead of another, these programs can be a cause for concern even within Canada. A 1982 book by Davenport *et al.*, *Industrial Policy in Ontario and Quebec*, examines the recent substantial growth of provincial financial assistance. The authors have estimated that provincial direct subsidies to industry grew from an annual level of \$1 million in 1970 to \$204 million in 1979 (Davenport *et al.* 1982, p. 12).

U.S. Subsidies

In general, most U.S. government assistance has been developed at the state rather than the federal level. An Office of Technology Assessment Study in January 1983, indicated that 153 state government programs had at least some factors directed toward high technology development and that of these, 38 were specifically dedicated to high-tech firms (United States, General Accounting Office 1983, p. 54). Most of these 153 initiatives were launched between 1980 and 1983. The study also revealed the range of diversified industries that states were attempting to foster. The two most sought after industries were those pertaining to computer software and biomedical activities (*Business Facilities*, 1984 p. H-23).

By the end of 1985, about 20 states had invested a total of \$200 million in venture capital pools (Watkins, 1985a, p. 20). The reasons for state involvement may stem from two factors. First, as emphasized by a recent U.S. Small Business Administration study, the initial seed capital phase of high-tech business development is the stage at which a private venture capitalist is least likely to take part (Hollis 1985, p. 6). Second, most venture capital firms are found in either California or New York and the few venture capital firms located towards the interior of the nation are reluctant to deal with local high-tech firms; for example, venture capitalists in the Mid-West account for only 11 per cent of the nation's total venture capital and

most of those funds go to firms located on either the East or West coasts (*Wall Street Journal* May 20, 1985).

States take part in venture capital programs in various ways. A state government may invest directly in firms, using funds from tax revenues, general obligation bond financing, or federal agency programs, such as the Economic Development Administration (EDA) of the U.S. Department of Commerce. An example of such direct state investment can be found in the Connecticut Product Development Corporation (CPDC). Created in 1975, the corporation provides risk capital for new products and procedures and typically receives royalty payments (Babbit 1984, p. 58). The CPDC also runs two other financial programs for firms producing new products: a start-up program provides funding for firms in the start-up phase of development and the Connecticut Innovation Development Loan Fund which provides, through a revolving capital loan fund, low interest loans to companies with innovative new products (Hollis 1985, p. 56).

Illinois offers grants to universities, research groups and small businesses for projects that lead to new product development. Either products or services are eligible for the program, but they must be marketed by in-state firms. Furthermore, these funds can be used towards any aspect of the "commercialization of the product or service, including R and D, marketing, location of additional funding, or establishing or upgrading technology transfer networks" (*Business Facilities* November 1984, p. H-10).

The New York Corporation for Innovation Development (CID) provides assistance to technologically based new business ventures or new product/process development in existing business in federal EDA eligible areas. Assistance is granted to small, locally-controlled businesses that demonstrate substantial benefits to the state, usually through employment and infrastructure improvements. The projects must be ready to be marketed and the entrepreneur must obtain a 3 to 1 match in additional funds from other sources (Watkins 1985b, p. 32).

State participation in venture capital initiatives can also be indirect. The most common form is to create a state-legislated corporation in which the private sector is encouraged to undertake economic development on behalf of the state (Hollis 1985, p. 8). Such a corporation can be a profit or non-profit organization. Tax reductions or tax credits which are equal to a predetermined percentage of the investment are often used to entice private investment in such a corporation (Hollis 1985, p. 11).

An example of a state-legislated corporation is the Massachusetts Technology Development Corporation (MTDC). This independent non-profit public venture capital firm was created in 1979 to provide technical assistance and start-up capital to small

innovative technology-based businesses. The only restrictions are that 50 per cent of MTDC investments must be in designated low income areas and that participating firms have not been able to secure conventional financing. By the end of the fiscal year 1985, MTDC had created 1,200 jobs and generated \$2 million in tax revenue (Watkins 1985b, p. 29).

Indiana and Utah are among the states that facilitate venture capital availability through tax breaks. Indiana's Corporation for Innovation (CI) is a private, for-profit corporation which was created in 1981 by the state legislature to "stimulate the growth of venture capital for investment in innovative small business enterprise" (Task Force on Technological Innovation 1983, p. 97). The corporation has been given the power to grant up to \$5 million in tax credits for private investments in its venture capital fund.

Some states, such as Utah, have approved a credit against the state income tax for investments in R and D Limited Partnerships (RDLPs) (*Business Facilities* November 1984, p. H-10). Such a partnership allows companies to work together to develop a product without violating federal anti-trust regulations. An interesting example of a RDLP is the Microelectronics and Computer Technology Corporation (MCC) in Austin, Texas. MCC is a cooperative research venture owned by 21 computer and electronics companies throughout the U.S., companies that could not afford to do the research by themselves. Each shareholder has exclusive rights to all innovations and products discovered by the partnership. The group is working on projects that deal with bottlenecks in computer research: artificial intelligence, semiconductor packaging, database management, parallel processing, software technology, computer-aided design of integrated circuits and interaction between people and computers (*Wall Street Journal* December 24, 1985).

In 1984, American state and local public pension fund assets totalled over \$200 billion. Approximately \$600 million, or less than half of one per cent, was invested in venture capital investments (Watkins 1985b, p. 20). Between 1978 and 1984, 25 state pension funds liberalized the investment criteria of their systems in favour of venture or small business investment (Hollis 1985, p. 29). Michigan ranks as one of the largest pension fund venture capitalists with \$500 million available for investment in 1986 (Blanchard 1986, p. 8).

Subsidy Pacts

Certain private sector investments may provide the society as a whole with externalities or public benefits such as new job opportunities, a larger tax base, and a market for the products of existing firms. Those countries for whom a certain private sector investment would provide

the greatest externalities or public benefits may be expected to offer the highest subsidies to attract that investment. Suppose that an international agreement imposes limits on subsidies to a stipulated level. With such a subsidy pact, investments and production will not be located in the country where they may provide the greatest public benefits. The lower the maximum permissible subsidy level the greater will be this effect. Generally, externalities or public benefits will be of most value to those countries or regions with the highest rates of unemployment, and so these may be the territories most hurt by such a non-competition pact.

In recognition of these problems, the EEC in its subsidy pacts has established four different subsidy levels. The poorest regions, with highest unemployment levels, are permitted to offer the largest subsidies to attract new private sector investment. In the first, and poorest area, the ceiling on aid is set at 75 per cent net grant equivalent of initial investment. In the second group, the ceiling is set at 30 per cent net grant equivalent. In the third group, the ceiling is set at 25 per cent net grant equivalent. For the final group, which comprises the major part of the EEC, the ceiling is set at 20 per cent net grant equivalent (Schwartz 1983, p. 401).

In each non-competition pact, regulators such as those who set the EEC subsidy levels will need to retain the right to alter those levels; that is, a non-competition pact of this type should provide for changes to be made whenever the regulators see that the ratios are indeed causing undesirable investment patterns. The process of establishing such ratios may involve political trade-offs and non-economic elements. In Canada, substantial discussion has focused on the impact of tariffs on different regions of the country and the question of the regional beneficiaries of tariff reduction. Such discussion will probably shift its focus to subsidies, and regional political forces will advocate their respective interests in any subsidy pact negotiations.

A pact of this type also exposes all of its participants to the risk that non-signatories will gain benefits from the pact. Firms whose operations create externalities having a value to society higher than the permissible subsidy levels will consider locating where they are not subject to the pact and where they can obtain higher subsidies. Hence, the participants in a pact may deprive themselves of a set of potential investments. In these cases, the extent to which such a pact can achieve its objective will depend on the degree to which firms can locate in non-pact jurisdictions. The post-1945 expansion of international investment suggests that such a pact will become less useful as time passes. Firms are increasingly able to shift production facilities to other countries, particularly with recent and projected decreases in tariff barriers.

A subsidy pact that deals only with new investment may shift the competitive bidding towards bail-out subsidies, as pact members strive more vigorously to retain investment they already have. The extent to which such bail-out competition will intensify will depend on the degree to which the subsidy pact forces new investment to other countries. Therefore, a subsidy pact which firms can avoid through international investment may cause particularly severe difficulties in terms of bail-out competition among the signatories.

A subsidy pact may also focus on a particular type of subsidy, such as government export financing. At present, a consensus exists among 22 industrial countries, establishing minimum government interest rates for export financing. The comments above are also applicable for such agreements. In particular, recent changes in interest rates and exchange rates have emphasized the need for flexibility in the provisions of such a pact. Recent amendments to the OECD understanding provide a formula for automatic adjustments in permissible interest rates for export financing.

A 1985 Government of Canada publication provides an overview of this issue.

Official export financing among OECD countries is subject to OECD Consensus guidelines on maximum maturity limits in a range of 8 1/2 to 10 years, minimum cash payments (down payments) of 15 per cent, and minimum interest rates for the three categories of countries classified by degree of development, with higher rates for "rich" countries. These rates are subject to adjustment semi-annually to reflect changes in market interest rates. The last changes took effect July 15, 1984 when minimum rates were increased by 1.2 per cent. They now stand at 10.7 per cent for "poor", 11.9 per cent for "intermediate" and 13.6 per cent for "rich" countries. On January 15, 1985 these rates were to decline in line with recent lower market interest rates. For currencies where market interest rates are below OECD Consensus rates, a system of commercial reference interest rates apply (e.g., for the Deutsche mark, Swiss franc, Japanese yen, Dutch guilder).

The Consensus does not cover all sectors. There is a separate agreement for nuclear power plants. Ships, other than offshore "rigs," are covered under another OECD understanding. Aircraft are not yet covered by the Consensus but it is hoped that negotiations on an agreement will be concluded in 1985. Export credits for agricultural and military products are not subject to the

Consensus. Negotiations on export credits of agricultural products are under way but progress is expected to be slow (Canada 1985b, p.3).

The Problem of Defining Subsidies

Negotiation of a subsidy pact also has to deal with the difficult question of defining subsidies; since the definition chosen will affect the nature of the pact. The following examples illustrate this point:

1. *Inclusion of State, Provincial, and Municipal Assistance as Subsidies Under the Pact*

Since all levels of government provide goods and services at less than market prices in a manner that subsidizes the costs of private firms, a subsidy pact will be different from agreements by national governments aimed at tariff reductions. In both Canada and the United States, it is difficult to imagine effective national government commitments which control the actions of sub-national governments within their borders. The mechanics for including provincial and state governments in negotiations would be new for many participants, and the process somewhat unclear. Even the constitutional division of powers entails ambiguities which could become important in such negotiations. A pact that includes sub-national governments will probably have to focus initially on a narrow and precise definition of subsidies, with gradual extensions in future agreements to include additional types of government assistance.

Of major significance are the provision of government capital at interest rates below those prevailing in the market and of government guarantees for corporate loans from the private sector. More dramatic, perhaps, are government subsidies which bail out firms considered to be in such severe distress that they would close some or all of their operations if not granted financial assistance (Chandler *et al.* 1986). Capital assistance can be directed at many objectives other than bail-outs. A 1982 study by the Economic Council of Canada has documented dozens of Canadian federal and provincial government programs that provide loans and loan guarantees. This study uses the government bond yield to estimate the amount of subsidy involved in the special interest rates charged for these loans (Economic Council of Canada 1982). Calculating the subsidy component of such assistance and relating that component to a particular firm at a particular time is extremely difficult and necessarily involves imprecise estimates.

2. Government Tax Concessions

Special tax concessions can also reduce a private firm's costs and provide a competitive advantage to much the same extent as direct subsidies. Consequently, it is likely that governments negotiating a subsidy pact will wish to include special tax concessions in such discussions. On a general level, some countries have relied on a value-added tax which is not payable on exports. In countries that impose corporate income taxes instead of value-added taxes, the argument can be made that foreign competitors' firms are being subsidized by the VAT export-rebate programs.

3. Cultural Subsidies

Canadian governments have developed significant subsidy programs to stimulate the growth and refinement of a distinctive culture (Lyon and Trebilcock 1982). Some such activities reduce the level of Canadian spending on non-Canadian cultural activities. In July 1982, for example, a federal government fund of \$230 million was established to assist Canadian television production over the next five years. Arrangements are made on the basis of \$1 of public money to match every \$2 of private money. Together with this explicit subsidy program, the government also introduced additional tax concessions for such private investment (*Globe and Mail* October 27, 1983, p. 67). No doubt some recognition must be given to a nation's desire to strengthen its cultural identity, and some level of subsidy must be permitted for this purpose. What level of such activity and what types of programs exceed reasonable behaviour and so should become the subject for international subsidy negotiations? The issue of tax deductibility of Canadian advertisements in U.S. magazines has shown that such cultural protection can cause bitter reaction and significant retaliation abroad.

Preferential Treatment for Domestic Investors

The exclusion of foreign investors from some of the subsidies offered to domestic investors has created another area of potential conflict that could be the subject of international negotiations. To qualify as having Canadian content, film productions must fulfill an arbitrary set of nationality requirements in terms of the individuals in such productions. Special assistance to the exploration activities of oil companies through the Petroleum Incentives Program (PIP), "which establishes a system of incentive payments for exploration and development on a scale reflecting the degree of Canadian ownership and control" (Stern 1985, p. 46) leaves foreign-owned firms at a

competitive disadvantage even if their performances within Canada are no different from those of Canadian firms. "The objection to the PIP is that it violates the principle of national treatment by making the incentive payments conditional on the degree of Canadian nationality and control of firms" (Stern 1985, p. 47). Within any subsidy pact, an important question will be the right of access by foreigners to the subsidies being offered, and the conditions that should govern that access.

Adjustment Assistance and Subsidy Pacts

New international trade agreements may have to be accompanied by new subsidy programs aimed at providing adjustment assistance to firms and employees whose production is displaced by imports. Increases in exports create jobs; increases in imports often threaten jobs and require costly adjustment on the part of domestic producers competing against the imports. For the population as a whole, an increase in imports that are less expensive or of better quality and greater variety than domestic goods, may be of great importance. But individual citizens do not stand to gain sufficiently to justify active lobbying for new trade agreements to increase imports. In addition, the beneficiaries of the new business opportunities created by such agreements may be future corporations and future employees, who have no voice in today's debate. On the other hand, increased imports would hurt a relatively small group of producers and employees, who may see their potential losses as so great as to warrant powerful political lobbying. In such a situation, a government may choose not to maximize the gross national product (GNP) but rather to cater to the vocal segment that fears possible injury.

The political strength of these vested interests is likely to be greater if they are clustered in a specific region or province. High concentration may automatically win the support of their provincial government. Furthermore, their cries of hardship may be more justified to the extent that regional concentration makes readjustment to new trade conditions more difficult. That is, entire communities could be compelled to transform their industrial structures, a process that is more difficult than if the adjustments were evenly dispersed across the country.

New trade agreements will always threaten to hurt some individuals, some corporations, some economic sectors, and some geographical regions. Those who fear they will be hurt not only object to such changes but, quite naturally, also often lobby for special government assistance to compensate for their losses (Glenday *et al.* 1982). For a country as a whole, such adjustment assistance may be a wise policy (Saunders 1984). We may well have reached a crossroads

at which any significant shift in direction will have to involve such assistance. Without it, political agreement on the pursuit of a new direction may not be possible. Thus, new trade agreements may have to include adjustment assistance in the form of subsidies as an essential component of the arrangements.

Enforcement Mechanisms with Subsidy Pacts

A discussion of enforcement of subsidy pact provisions crystallizes the ambiguities and complexities of this subject. State, provincial, and local governments cannot be prosecuted before international judicial bodies. The place of such governments in international agreements and enforcement bodies will always be unclear. Definitions of subsidies are necessary for compliance and essential for enforcement. Yet such definitions will not be developed easily. A wide array of government activities can act as substitutes within the subsidy field, and the prohibition of a few specific types of financial incentives may well lead to a shift to the use of other types of financial incentives. Furthermore, many programs such as those assisting R&D can be tailored so that in practice, they benefit only one firm or perhaps a few.

An injured nation may have difficulty in retaliating directly against a violator of the pact without at the same time punishing all the signatories. An illustration of this type of problem was the 1983 U.S. restriction of specialty steel imports in retaliation against EEC subsidies. As noted by Stern (1985), "U.S. actions to restrict imports of specialty steel during 1983 were aimed primarily against government steel subsidies in certain member countries of the European Economic Community (EEC). Yet Canada may be affected adversely even though its exports are not subsidized. Thus, Canada may find its economic interests damaged by U.S. policy actions in cases when it is, so to speak, an innocent bystander" (Stern 1985, p. 39). This "innocent bystander" problem is likely to occur regularly in the enforcement of subsidy pacts. The new Canada-U.S. trade agreement seeks to limit U.S. action of this type.

In addition, "Canada's exports of selected steel products to the U.S. may have been adversely affected by relief granted to U.S. producers under the Trade [Agreements] Act [of 1979]. In this case, countries other than Canada represented the source of the alleged difficulties, but the policy of restraint made no distinction among supplying countries" (Stern 1985, p. 52). The U.S. Trade Agreements Act of 1979 rests upon a "material injury" requirement. As such, it relies on complaints by U.S. firms; and it provides for the U.S. imposition of countervailing duties if such injury is proven. In 1982 Rodney de C. Grey referred to these types of provisions as "a system"

and described "the increasing legalization of trade relations" caused by this reliance upon contingency protection. He has gone so far as to state, "Nor is it clear that GATT is now about trade liberation. Rather, it is about trade policy regulation" (Grey 1982, p. 17).

In this process of enforcement and regulation, interesting questions will arise concerning the effectiveness of one's ability to retaliate if injured. Important to this will be the nature and extent of one's relations with the violating government. For example, Canada's ability to enforce a pact will be much less than that of the United States. Small signatories will have to rely on joint retaliation or on the goodwill of larger members.

Political elements will no doubt enter the enforcement and dispute-resolution mechanism. This has been illustrated in the U.S.-EEC 1982 steel subsidies conflict:

The Reagan Administration had repeatedly voiced its resolve to stay out of the conflict and not to interfere with the steel industry's efforts to seek relief under the laws of the land from alleged unfair competition. This resolve did not endure, however. What had begun as private legal action turned into a bitter international dispute and, also, as on previous occasions, high-level government officials soon found themselves engaging in "shuttle diplomacy." (Mueller and van der Ven 1982, p. 262)

In 1982, the Ontario Ministry of Industry and Trade published its position on these enforcement issues in a document, *Canadian Trade Policy for the 1980s: An Ontario Perspective*. The following quotation indicated Ontario's views and also provided an insightful commentary on the shortcomings of the existing GATT procedures:

The various concepts of injury both in relation to unfair trade practices, as in the Antidumping and Countervailing Codes, and to disruptive trade, as in the Safeguards Code, have never been defined to GATT signatories. It is, therefore, left primarily to domestic legislation and practice to give interpretation of these key concepts. In a number of countries, moreover, national legislation is not sufficiently consistent with the GATT codes, thus creating disparities between levels of import protection afforded to domestic industry in different countries.

In order to encourage consistent, multilaterally accepted interpretations of key GATT terms and concepts to ensure that these emerge by way of negotiation and agreement

between signatories, rather than primarily by the weight of U.S. practice, Canada should be seeking further clarification of these codes at the multilateral level. With such a dependence on exports, Canada has a particular interest in ensuring that the threshold of pain, the criteria for material injury, and the required causal link between imports and injury are not overly loose. Ontario, therefore recommends that

agreement be sought to review and clarify definitions of injury in existing GATT codes with a view to laying the basis for more consistent multilateral interpretations of these codes.

The ability of the GATT system to establish appropriate mechanisms and procedures for dispute settlement between signatories is a central element of the system and the basis of much of its legitimacy and credibility. This credibility is undermined if dispute settlement procedures are not adhered to and results of these procedures not respected. Ontario, therefore, recommends that:

Canada commit itself to support and respect the results that emerge from the GATT dispute settlement procedures and firmly encourage similar adherence by other signatories, such as the United States, which continues to try to negotiate out of having to accept the fact that DISC is a breach of its GATT most-favoured-nation obligations.

Canada should also come forward with some constructive criticism of GATT dispute settlement mechanisms (notifications, consultation, surveillance, dispute settlement) with a view to encouraging review and improvement of certain aspects of the mechanisms. This would include proposals for examination of such issues as delays in adopting terms of reference of panels, delays in forming panels, time limits and enforcement of decisions. (Ontario, Ministry of Industry and Trade 1982, p. 8)

Conclusions

We conclude this chapter with a series of observations in regard to intergovernmental negotiations concerning subsidies.

- The negotiations will be extremely complex, more so than traditional tariff negotiations. In particular, they will have to deal with problems of definition and with the ability of signatories to switch their financial assistance to forms that have not been prohibited, and they will have to cope with new enforcement problems.
- Agreements to reduce the level of subsidies may conceivably reduce the welfare of the signatories. Countries or regions of high unemployment may be limited in the subsidies they can offer, while areas outside of the pact may gain through their unrestricted ability to offer subsidies.
- Sharing information in regard to the subsidy-investment-externality process may reduce errors in estimation of optimal subsidy levels and, consequently, may improve the well-being of all participants.
- An optimal subsidy pact will probably involve a set of pacts, some dealing with specific types of subsidies, and some dealing with specific firms. In particular, subsidies to firms possessing market power and considering large investment or production decisions may require special intergovernmental negotiations case by case. This will probably be true for aircraft, automobiles, energy, petrochemicals, and defence equipment.
- An optimal set of pacts will have to provide for review and adjustments to its provisions on a frequent or continual basis. A permanent structure for such review may deserve consideration.
- In negotiations, all levels of government will have to be involved. This contrasts in fundamental ways with traditional tariff negotiations, which have involved only national governments.
- Negotiations will have to consider the impact of a subsidy pact on trade with non-signatories. Pursuant to tariff negotiations, concessions can be extended to other governments whenever the latter choose to participate in the agreements. With a subsidy pact, non-signatories may automatically benefit from signatories' reductions of subsidies without themselves providing any concessions. This factor alone is a sufficient condition to necessitate review and flexibility with a subsidy pact, as experience accumulates and as circumstances change.

- Externalities may spill over into other jurisdictions. In this case, a pact to pool subsidies and rationalize subsidy offers could make all participants better off than if the investments went elsewhere. This could well be the case with some Canadian and U.S. subsidies.
- Analysis of the externality-subsidy relationships and the process of negotiating subsidy pacts will rely heavily on studies of specific firms, production processes, groups of unemployed workers and regional disparities. This industrial organization approach will involve elements not central to traditional trade theory – elements that seek, through cost-benefit calculations, to place estimates on the various aspects of the externality-subsidy relationships. Consequently, sector by sector analysis and negotiation may be the most appropriate, together with the recognition that this must be a continuing process.

Chapter X

Government Procurement

Introduction

Most governments prefer to purchase equipment and services from their domestic corporations rather than from foreign firms. Official procurement programs create special advantages for local corporations, and informal procurement practices also give them advantages over foreign competition. Governments can use their procurement policies to stimulate the development of high-tech firms. In this chapter, we describe current Canadian federal and provincial practices, as well as those of European countries and the United States. We present a discussion of U.S. defence procurement because it has been the most important instrument used by the U.S. government to stimulate high-tech. Growth and innovation in the U.S. information technology sector has depended largely on defence contracts and on the commercialization of products created for the U.S. military. The Tokyo round of GATT negotiations resulted in an agreement to limit the use of procurement policies that favour domestic firms. We consider the degree to which this code limits Canadian governments in their domestic preferences. As a practical matter, we suggest that public servants and politicians seem able to avoid the provisions of any procurement agreement easily. For the information technology sector, the growth of solution selling involves a wide variety of products and services, and this introduces differences among competing bids. Faced with bids that are not strictly comparable, the purchasing government can devise any number of

excuses for favouring domestic firms. Hence, the design and implementation of procurement policies – both here and abroad – will remain of central concern for Canada and its information technology sector.

In 1983, the Canadian government appointed a task force to consider "Federal Policies and Programs for Technology Development." Its 1984 report emphasized the importance of government purchases as a mechanism for supporting innovation and productivity.

Procurement is one of the most effective means by which government can promote technology development. Ottawa's vast purchasing power is a tool – so far insufficiently used – which could provide the market "pull" for the development of a host of new products, technologies and even industries. Every government department with substantial purchasing commitments must be required to include technology development among its major priorities (p.39).

It is clear that procurement policies can serve objectives other than technological development. Of particular importance is the creation of new jobs, particularly in economically depressed regions. Generally, all such objectives lead a government to institute preferences for domestically produced goods and services. Regardless of the rationale for such domestic preferences, procurement policies affect the ability of foreign companies to compete for Canadian government contracts.

Andrew Moroz suggests that total direct purchases by all governments in Canada amount to about 10 per cent of the gross national product (GNP). If federal and provincial Crown corporations, agencies, hospitals, and educational institutions are included, then public purchases reach about 18 per cent of GNP (Moroz 1985, p. 251). These amounts are large enough to have a significant impact on the prosperity of thousands of individual corporations. It is clear that the task force's recommendations could result in a stimulus to technology development.

However, extremely important questions concern whether this stimulus should be directed solely to Canadian corporations. Should foreign firms be excluded from particular bids? Should Canadian firms have preference? What form should such preference take? The answers to these questions will affect the volume and content of Canadian imports. Consequently, other nations will want to discuss Canada's procurement policies during trade negotiations. Conversely,

Canadian corporations will be equally concerned about their right to bid on the contracts for purchases by foreign governments.

The federal government's purchases of high-tech constitute a significant market for the information technology industries. Table 10.1 provides data concerning federal government purchases of information technology products for the fiscal year 1984-1985. These data are broken down by department and by type of equipment. Purchases totalled \$233 million for communications equipment; \$194 million for electronic/automated equipment; \$163 million for specialized equipment, and \$28 million for office machines and equipment. The grand total for all four categories reached \$619 million. This indicates that information technology industries face a substantial market in federal government procurement. Provincial government purchases would supplement these figures.

Federal and Provincial Government Procurement Policies in Canada

In a report prepared for the MacDonald Royal Commission, Andrew Moroz summarized the current practices of the federal government:

There is no "buy Canadian" act that sets out the rules and procedures for federal purchases of non-defence goods and services. Instead, there is a maze of administrative rules and guidelines, ranging from informal general price preferences to administrative bans on imports of certain goods, which constitute an extensive system of "buy Canadian" practices. Federal procurement of non-defence goods and services is largely regulated by the Financial Administration Act, government contract regulations, certain chapters of the Treasury Board's administrative policy manual, and the Department of Supply and Services' supply policy manual. The main feature of the federal procurement system is the discretionary administrative approach to federal purchases.

The most important federal agency controlling the federal government's procurement of goods and related services is the Department of Supply and Services (DSS). It acts as a central purchasing agent for most federal departments and contracts about 40 per cent of the total federal purchases of goods and related services. Major purchases of non-defence goods and related services include communications equipment, chemicals and chemical products, and scientific instruments and laboratory equipment.

Table 10.1
Federal Government Purchases of Machinery and Equipment: 1984-1985

Department	Communications Equipment	Electronic/ Automated Equipment	Specialized ¹ Equipment	Office Machines and Equipment ²	Sub Total	Other ³	Total Purchases
				(millions)			
Agriculture	0.84	9.10	16.41	0.31	26.66	16.69	43.35
Communications	2.23	4.98	1.12	0.71	9.04	7.78	16.82
Consumer and Corporate Affairs	0.12	2.17	1.19	0.36	3.84	1.35	5.19
Economic and Regional Development	0.02	--	--	--	0.02	0.01	0.03
Employment and Immigration	1.18	17.75	0.02	2.39	21.34	2.06	23.40
Energy Mines and Resources	2.61	15.79	12.38	0.22	31.00	8.26	39.26
Environment External	1.87	9.89	13.09	0.41	25.26	12.19	37.45
Affairs	4.34	3.65	1.60	2.34	11.93	19.22	31.15
Finance	--	3.55	--	0.02	3.57	0.92	4.49
Fisheries and Oceans	1.92	4.78	7.72	0.30	4.72	53.34	68.06
Governor General	0.16	0.01	--	--	0.17	0.02	0.19

Table 10.1 (continued)

Department	Communications Equipment	Electronic/ Automated Equipment	Specialized ¹ Equipment	Office Machines and Equipment ²	Sub Total	Other ³	Total Purchases
(millions)							
Indian and Northern Development	0.43	0.91	0.60	0.60	2.54	3.92	6.46
Justice	0.68	0.87	--	0.49	2.04	1.45	3.49
Labour	1.50	0.27	--	0.15	1.92	0.36	2.28
National							
Defence	103.38	37.92	40.79	7.28	189.37	2 148.19 ⁴	2 337.56
National Health and Welfare	0.42	4.14	9.56	1.02	15.14	4.85	19.99
National							
Revenue	1.47	18.83	1.38	0.20	21.88	4.01	25.89
Parliament	3.25	2.86	--	0.50	6.61	1.89	8.50
Privy Council	0.34	1.18	--	0.14	1.66	0.61	2.27
Public Works	1.73	7.14	8.83	0.41	18.11	15.96	34.07
Regional							
Industrial Expansion	0.18	1.92	--	0.13	2.23	0.68	2.91
Science and Technology	3.39	9.39	38.92	0.03	51.73	5.34	57.07
Secretary of State	0.45	2.38	--	1.22	4.05	1.77	5.82
Social							
Development	--	0.01	--	--	0.01	0.01	0.02

Table 10.1 (continued)

Department	Communications Equipment	Electronic/ Automated Equipment	Specialized ¹ Equipment	Office Machines and Equipment ²	Sub Total	Other ³	Total Purchases
(millions)							
Solicitor General	22.20	5.83	4.52	4.68	37.23	42.62	79.85
Supply and Services	2.54	15.84	--	0.32	18.70	4.10	22.80
Transport	75.87	12.12	4.95	3.43	96.37	329.24	425.61
Treasury Board	0.61	0.06	--	--	0.67	0.02	0.69
Veteran Affairs	0.05	0.55	0.15	0.41	1.16	1.54	2.70
Total	233.79	193.89	163.23	28.03	618.94	2 688.42	3 307.26

1. Category includes items such as measuring, controlling, laboratory, medical and optimal instruments, apparatus and accessories, safety and sanitation equipment, alarm and signal systems.

2. Excludes electronic and automated equipment.

3. Comprises Transportation Machinery and Equipment; Amunitions and Weapons for Defence; Furniture and Fixtures; Industrial Machinery and Equipment; Electric Heating, Air Conditioning and Refrigeration Equipment, and Other Machinery and Equipment.

4. Includes \$387.11 million in purchases of ammunition and weapons for Defence and \$1 645.85 for ships, tanks, aircraft etc.

Source: Public Accounts, 1984-85.

The DSS procedures for purchasing goods and related services show two major forms of domestic preference: a priority classification of domestic sources as opposed to foreign sources in the bid solicitation system, and an informal premium for domestic content which allows Canadian producers to bid above the prices of bids from foreign sources and still be awarded the contracts. The informal premium is 10 per cent of the difference in the amount of Canadian content in each bid. The selection process, however, is perhaps the more effective form of discrimination. The DSS uses a source list identifying qualified bidders, and suppliers are divided according to four priority classifications:

1. Canadian-based manufacturers producing in Canada, including Canadian-based manufacturers who have "rationalized" their production to the benefit of Canada but do not produce the specific product in question in Canada
2. Canadian-based companies providing suitable after-sales service but acting as agents of foreign manufacturers
3. other Canadian-based companies acting as agents of foreign manufacturers, and
4. foreign-based manufacturers.

The DSS usually restricts the selection of sources to the first group if there are three or more eligible sources. Furthermore, most major contracts are filled without going through the public tender process, with over two-thirds of the value of total DSS purchases negotiated directly with preselected suppliers.

The bulk of federal government purchases from the private sector are services, the largest single item being construction services. Federal procurement of construction services is largely administered by the Department of Public Works. Canadian preference occurs in the form of a standard clause in construction contracts requiring the general contractor to employ Canadian material and labour to the maximum extent feasible. Other important federal purchases of services include R&D, printing, and business services, and these purchases are governed by the DSS guidelines. Crown corporations and other federal agencies,

such as Air Canada and Canadian National Railways, are also expected to follow the DSS guidelines.

Other general features of the federal government procurement policy for purchases of non-defence goods and services include the Source Development Fund, which subsidizes companies developing products procured by the federal government for which no Canadian sources presently exist, and the Unsolicited Proposals Program, which encourages R&D project proposals and is heavily oriented toward Canadian-owned R&D firms. In addition, companies bidding on contracts worth more than \$2 million must submit in their bid a Canadian business opportunities plan documenting the subcontracting intentions in the tender. The federal government has further specified that 40 per cent of its purchases must be from small business. It also takes direct account of regional sourcing in its evaluation process. For large on-going contracts awarded to foreign-owned multinational enterprises, the policy is to negotiate offsets in terms of product mandates and R&D mandates for their Canadian subsidiaries (Moroz 1985, pp. 251-253).

To ensure that all regions in Canada benefit to the greatest possible extent from contracts issued by the Department of Supply and Services, internal DSS policy states that goods and services should be purchased as close as possible to the ultimate point of consumption. To meet this objective, DSS seeks to direct an increasing number of requisitions from headquarters to regional operations. While the vast majority of purchases are made by regional operations these represent only a relatively small percentage of the value of total purchases (20 per cent). As regional purchases are limited to the region in which they are to be used, this might be considered a non-tariff barrier to trade.

Canadian provinces have their own procurement practices, and these also entail preferences for domestic manufacturers (Trebilcock *et al.* pp. 243-252). Some provinces restrict these preferences to firms located within their own borders, while others – such as Ontario – give uniform preferences regardless of province of origin. Ontario has established an Office of Procurement Policy to coordinate the maximization of domestic content in government purchases and to assist ministries and publicly funded agencies in making the appropriate calculations.

Most provincial governments give some implicit or explicit preference to provincially-made goods. The extent and form of the

preference vary from one province to another and stem from purchasing policy rather than law. To the extent that purchasing preferences favour local firms as opposed to firms that are more cost competitive, such practices could, in the long run, lead to inter-provincial fragmentation of the industrial structure.

There are three distinct ways in which preferences can be given on a government purchase, and the extent of the preference is not always easy to identify. The three techniques are as follows:

1. *Requirements definition.* Governments often set their own performance requirements for items they buy. If those standards are tailored closely and exclusively to the capabilities of firms within the province, this could constitute an interprovincial non-tariff barrier to trade.
2. *Sourcing policy.* Most governments maintain source lists of producers who can supply wanted commodities. To the extent that firms outside a province have more difficulty getting on such lists than firms inside, or are not invited to tender, this constitutes a form of preference.
3. *Tender evaluation.* Conceptually, preferences are easiest to spot and measure at this stage. If an in-province bid for some commodity is accepted despite its being higher than an out-of-province bid, the magnitude of the preference might be deemed to be the difference between the two.

Provinces normally urge local governments, hospitals and universities under their jurisdiction to follow the provincial procurement practice. In addition, in some provinces, provincially-owned utility companies adopt a buy-provincial policy.

Canadian Defence Procurement

For every nation, defence procurement presents special difficulties. In the event of war, domestic corporations would presumably be much more secure as sources of supply than would foreign corporations. Not surprisingly, governments have consistently preferred domestic corporations if those corporations have been able to manufacture appropriate equipment. As noted above, defence procurement is exempted from the GATT code. It is unlikely that any future negotiations will be able to alter this established practice. Rather, we may expect to see bilateral negotiations, usually involving both governments as well as private corporations, in any international sales of defence equipment.

Other factors also support this view. In the interests of domestic job creation, a purchasing government will usually negotiate to maximize the provision of components by domestic firms. These "offsets" can involve discussions and agreements among many corporations and the purchasing government, with the joint objectives of maximizing local employment and obtaining the best possible value.

Sales of military equipment are an important aspect of international political relationships. They are not solely an economic activity. To the degree that such sales involve secret technology and to the degree that they can affect a balance of power, a number of governments may be involved in any one procurement decision. "Competitive" and "fair" bidding may simply not be a realistic approach to such procurement.

For Canadian manufacturers, the Defence Production Sharing Arrangement between Canada and the United States does offer a mechanism for bidding on U.S. contracts. No tariffs apply to Canada-U.S. trade in military equipment, and the agreement stipulates that a rough balance should be struck in trade flows. This provision is of real benefit to Canadian exporters. The Defence Production Sharing Arrangement means that Canadian manufacturers already have a free trade agreement as well as a guarantee of a minimum level of exports to the United States. However, as a MOSST discussion paper (1985) indicates, while the agreement has been responsible for a significant increase in volume of trade between the two countries, it has not prevented a large increase in Canada's trade deficit in these products (Canada, MOSST 1985, p. 11).

Procurement Policies in Other Countries

American states, like their Canadian counterparts, have created their own individual procurement policies.

The recent proliferation of state Buy American laws and regulations has brought to 37 the total number of states with such restrictions. Congress passed the Surface Transportation Assistance Act in 1978 and has tied Buy American restrictions to other federal appropriations laws such as the Public Works Employment Act or the Clean Water Act. Under such legislation, state or local governments receiving federal funds for financing projects are required to apply Buy American restrictions to such projects. In practice, this means that more than 50 per cent of the content must be American and that the final assembly take place in the United States. An even more

stringent proposal to raise the content requirement from 50 to 70 per cent is currently being pushed in Congress and at the state level. In addition, some states have passed their own procurement laws and regulations specifying a level of domestic preference which may range as high as 20 per cent.

Such U.S. legislative actions have hit certain Canadian producers hard, particularly the Buy American provision under the Surface Transportation Assistance Act (Canada, Senate Standing Committee, 1982, p. 13)

A 1986 publication by McAfee and McMillan summarizes the procurement policies in the United States, Canada, Europe, Japan, and Australia. In the context of their European analysis, they emphasize an important characteristic of these policies: "The policies are rarely formally stated in law; instead, decisions are made administratively, on a case-by-case basis, often with little or no public explanation of why a particular contractor was selected" (McAfee and McMillan p. 8). While subjective judgment and informal preferences are part of every government's procurement practices, these are of particular importance in Europe and Japan.

Unlike the Canadian and United States governments, European governments do not explicitly state formulas by which foreign bids are to be compared with domestic bids; thus the extent of the protection is difficult to observe. Instead of applying a formula, governments achieve favoritism towards local firms by a variety of methods: allowing only a short time for the submission of bids; applying residence requirements on bidders; defining technical requirements in such a way that it is difficult or impossible for foreign firms to comply; or inviting only domestic firms to bid (Baldwin 1970, pp. 63-68).

U.S. Defence Procurement

For many countries, military procurement has been an important catalyst in fostering the growth of high-tech industries. In particular, some analysts note that the maintenance of a military advantage today is predicated upon a country's ability to remain at the cutting edge of the information technology industry (Kuwahara 1985, p. 11). Military and economic considerations have become intimately linked. The commercial applicability of R&D that was initially directed at military objectives has been more important in the United States than in other countries. One can see this linkage between military procurement and corporate innovations as a type of government subsidy.

The growth of modern high-tech industries in the United States was directly stimulated by World War II. The mobilization of scientists and engineers into war-related research was unprecedented and, as Table 10.2 illustrates, government support for research and development greatly expanded. Following World War II, federal support for research and development was maintained at levels significantly above the pre-war era and support was not specifically divided between economic and military applications. Kenneth Flamm (1987) states that the formation of U.S. policy was motivated "by the original and continuing link between technology and strategic advantage. The two objectives—economic and military—clearly were intertwined, and the precise rationale guiding policies was, therefore, easily confused" (p. 8).

The military budget continues to be a major responsibility of government. Much of the government support for research and development continues to be phrased in terms of defence objectives and the funding for many government research programs remains sheltered within the military structure. Largely as a result of this, the U.S. federal government spends more on research and development than the combined efforts of Britain, France, West Germany and Japan. It has been estimated that the total amount spent on research and development in the United States in 1986 was \$107 billion. Over one-third or almost \$40 billion of this total was devoted to defence. The percentage was much higher—reaching 85 per cent—for research in advanced technologies like lasers, sensing devices and computers capable of simulating human intelligence.

A significant application of defence spending is in the area of electronics. In fiscal 1984, the total defence-sponsored research in the United States as \$26.5 billion, of which approximately 46 per cent was research in electronics. The electronics component of the United States R&D effort has been integral to the development of new guidance systems, satellite communications and microwave receivers. Furthermore, the "Star Wars" program and the space shuttle have recently provided additional electronics contracts. In 1984, the Pentagon "procured \$87 billion in missiles, jets, ships, satellites, and vehicles that contained \$26.8 billion worth of advanced electronics" (Tatsuno 1986, p. 38). The procurement allocations of the Defence Department are planned to increase. As the Report of the Secretary of Defense for fiscal years 1988 and 1989 states, defence procurement for fiscal year 1989 has been set at \$94.6 billion (p. 87).

Military purchases create the preconditions for an influx of private industrial capital. The Defence Department allocates approximately 70 per cent of its research and development contracts to private companies (Cobb 1984). Furthermore, the Defence Department allocations to universities and colleges for specific

Table 10.2
U.S. Expenditures on Research and Development
by Source Funds, Selected Years, 1930-1961^a
(funds in millions of dollars)

Year	All Funds	Federal Funds	Per cent by Source		
			Federal	Industry	Other ^b
1930	166	23	14	70	16
1932	191	39	20	63	17
1934	172	21	12	73	15
1936	218	33	15	70	15
1938	264	48	18	67	15
1940	345	67	19	68	13
1941-45 average	600	500	83	13	4
1947	1 160	625	54	39	7
1953	5 207	2 759	53	43	4
1955	6 279	3 509	56	40	4
1957	9 912	6 119	62	35	3
1959	12 540	8 059	64	32	3
1961	14 552	9 624	64	33	4

Note: For 1930-1947, President's Scientific Research Board, John R. Steelman, Chairman, *Science and Public Policy*, Vol. 1: "A Program for the Nation" (GPO, 1947), pp. 10, 12; figures exclude research on atomic energy. For 1953-1961, U.S. Bureau of the Census, *Historical Statistics of the United States: Colonial Times to 1970*, biocentennial edition, pt. 2 (GPO 1975), p. 965. Figures are rounded.

- a. Statistics for 1930-1947 are not strictly comparable with later years because of changes in methodology and coverage.
- b. "Other" includes universities, colleges, and nonprofit institutions.

Source: Flamm, Kenneth (1987). *Targeting the Computer*. Washington, D.C.: The Brookings Institution, p. 7.

research and development activities is also significant. As shown in Table 10.3, Department of Defence funding for mathematics and computer science in 1986 was 59 per cent of all such federal funding.

Although the Defence Department's R&D efforts revolve around military applications, it is becoming increasingly difficult to distinguish research and development for military applications and those for non-military applications.

For example, in the Defence Advanced Research Projects Agency's (DARPA) Strategic Computing and Survivability Program, the first three years' share of military applications in the total budget was only 16 per cent. Large parts of this R&D budget are for the study of technology bases and infrastructure, and thus it is almost impossible to separate military R&D projects from other projects (Kuwahara 1985, p. 51).

Furthermore, the Defence Department is increasingly undertaking projects that will enhance both the military and non-military industrial processes in the future. The "Defence Manufacturing Initiative (DMI)" is one such undertaking that will seek to identify, promote and enhance not only the U.S. defence industrial base, but U.S. industry as a whole (Fiscal Year 1988 Report of the Secretary of Defence p. 142).

The procurement of an increasing amount of defence contracts is conferring upon the United States an important advantage in high-tech. Computer technology, space development, satellite and telecommunications systems, and advanced electronics have all been nurtured under the guidance of Defence Department contracts.

As Flamm (1987) notes, the Defence Department stimulated the emergence of the semiconductor industry and shaped its early development by demanding more versatile components for use in its weaponry.

... the Department of Defence in general and the Defence Advanced Research Projects Agency in particular have been the primary supporters of U.S. research on semiconductors constructed of exotic (that is, non-silicon) materials. In the late 1970s the military funded roughly two-thirds of all research on semiconductors made from the compound gallium arsenide (GaAs), the most important of these technologies (p. 71).

Table 10.3

**Federal Funding of Mathematics and Computer Science
Research in Universities and Colleges, Fiscal Years 1973-1986^a**

Year	Per cent funded by					All Five
	DOD	DOE ^a	NASA	NSF	NIH	
1973	47	4	1	45	3	100
1974	51	2	1	40	4	98
1975	43	3	3	45	4	98
1976	38	1	2	53	4	98
1977	40	4	1	48	4	97
1978	42	4	1	48	4	99
1979	47	5	1	43	3	99
1980	41	4	3	47	4	100
1981	46	4	2	43	3	99
1982	49	4	3	41	3	99
1983	52	3	3	38	2	99
1984	53	3	3	37	3	99
1985	55	6	3	33	2	99
1986	59	3	3	32	2	100

Note: NSF, "Federal Obligations for Research by Agency", pp. 5, 31; and National Science Foundation, Division of Science Resources Studies, "Federal Funds for Research and Development"; "Federal Obligations for Research to Universities and Colleges by Agency and Detailed Field of Science: Fiscal Years 1973-1986" (GPO, 1985), pp. 5, 9, 11, 17, 19, 21, 23, 27, 29, 37, 39. The data for 1985-1986 are NSF estimates based on the president's 1986 budget.

a. Per cent of federal obligations.

Source: Flamm, K. *Targeting the Computer*. 1987, p. 47.

The defence-related support given to research into semiconductors, and the expansion of the semiconductor into the computer markets created the situation whereby "this new industry literally exploded under the steam of ongoing technological innovation" (Saxenian 1984, p. 169).

Integrated circuits have also been a key element in fostering the growth of computer, telecommunications, and other high-tech firms. The foresight of the Defence Department in utilizing new developments in integrated circuits while the rest of the world was still producing transistors not only gave the United States the lead in innovations with silicon, but it also fostered the growth of several companies that pursued new integrated circuit technology.

The American direction was heavily influenced by the Department of Defence and NASA, which sought rugged, miniaturized devices for their different missions. In 1959 the Air Force contracted Texas Instruments to develop integrated circuits (ICs) for the Minuteman II missile, while NASA awarded contracts for the Apollo spacecraft computer to Fairchild, whose planar process (which involves etching IC designs on chemically-treated silicon wafers) was critical for large-scale IC production. In the early 1960s, twelve key military and space contracts were issued as U.S. production of ICs jumped from \$4 million to \$80 million. By 1963, worldwide industry sales passed the \$1 billion mark. During this period, Fairchild spun off new companies, such as National Semiconductor, Signetics, and Siliconix, which pursued new IC technologies (Tatsuno 1986, p. 11).

As in the past, the Department of Defence continues to foster the creation of new innovative technologies that will help to maintain U.S. leadership in the international weapons race. As the Fiscal Year 1988 Report of the Secretary of Defence illustrates, several programs will help foster new innovations in high-tech by emphasizing a synergy between the Defence Department, universities and corporations. Among these are the ManTech program, the Defence Software Initiative (DSI) and the University Research Initiative (URI).

In the ManTech program, the Department of Defence has put an emphasis upon machine tool technology; computer integrated manufacturing hardware and software; applications of artificial intelligence technologies and the development of advanced sensor technology (p. 143). Applications of such initiatives will improve

production technologies for both the Defence Department and private companies.

The Defence Software Initiative (DSI) is improving upon the reliability of computer software for defence systems. Research efforts will prove useful for the Defence Department, and they will also prove beneficial to the 40 companies and universities that will be working with the Software Engineering Institute to accelerate the applications of new software technologies (p. 247).

Finally, the University Research Initiative (URI) is another multi-disciplinary approach to defence research. Established in 1986, the URI will promote research programs at 70 universities in order to procure innovations in areas such as artificial intelligence, computer science, biotechnology, and high-frequency submicron electronics (p. 249). Although initial findings are earmarked for defence purposes, the industrial spinoffs of innovations in each of the above categories will facilitate the further growth of new private ventures.

Since the Nixon Administration, the Department of Defence has placed continued emphasis on defence procurement to foster regional economic growth and the growth of U.S. high-tech firms. Defence contracts have now become such a lucrative venture for U.S. companies, that we are witnessing a transformation of the U.S. high-tech R&D policy into a strategic aspect of U.S. regional development strategy. The U.S. high-tech industries have become so reliant on defence contracts that without them, there would certainly be a redistribution of economic activity throughout the United States.

It is commonplace that California is a heavily saturated defence area—especially around Los Angeles, where no fewer than seventy firms depend upon prime Pentagon contracts—and that it receives about a quarter of the total defence dollar by itself. Texas too, what with the Houston Space Centre and many major firms, has long been identified with the new Washington money. But few realize that even in such states as Louisiana, Georgia, Mississippi, Tennessee, and New Mexico, the defence industry is the single largest employer, an economic presence with enormous ramifications (Sale 1975, p. 26).

Defence procurement is seen as such a lucrative adjustment policy that many feel it has shaped not only the growth of U.S. high-tech, but also determinants of investment locations. As Senator Patrick Moynihan stated:

It is really in the hard areas—defence contracts, and [defence] procurement—where the Northeast loses out. In

the soft areas—welfare, medicare, and so forth—areas which don't help you build the economy, we do alright. In a sense we get the aid we need to stay alive, but not the contracts we need to grow (Morris 1978, p. 157).

Only about half of the federally sponsored research in the 1970s was defence-related. Today, it is the fastest growing category in the defence budget. The Department of Defence budgets for the 1988 fiscal year are an indication of where expenditures are heading. Since the Reagan Administration, the significant increase in the budget is on account of the new centrepiece of defence research, namely the Strategic Defence Initiative (SDI), or "Star Wars." For the United States, this has become the most important R&D project; more so than the Manhattan Project, or the Apollo Space program. Over the next five years, SDI is estimated to cost over \$26 billion, and will bring together the largest collection of scientists and engineers from around the world to participate in the development of one specific project. Furthermore, the technological breakthroughs envisaged from SDI would have important ramifications in future military and commercial applications. As Robert Reich (1985) states;

Spinoffs and applications, as yet unimaginable, could create whole new generations of telecommunications and computer-related products that could underpin information-processing systems in the next century (p. A23).

Meanwhile, not only is the Defence Department pursuing new technologies on its own, there are several countries, such as Canada and Japan, who will also participate in SDI research efforts. As a result, the importance afforded U.S. defence spending in the 1980s will also affect the nature and extent of other countries' high-tech policies.

GATT Procurement Code

The Tokyo round of GATT negotiations did include discussions concerning government procurement policies, and did result in an agreement signed by most of the GATT members (Whalley 1985, p. 68). Conferring national treatment on foreign suppliers, with regard to procedures in soliciting government procurement and extending the principles of non-discrimination to government procurement are the basic aims of the agreement. It provides for mechanisms to discourage a national government from discrimination when soliciting bids. Two important areas on which the Tokyo agreement focused are tendering and conditions for participation.

For tendering, procedures for the solicitation of bids must be published and suppliers must be given adequate time to complete the qualification procedure. Governments can solicit bids by three methods: the single tender method, the selective tender method, and the public or open tender. The single tender method is the most discriminatory because it invites a bid from only a single supplier. The selective tender method and the public tender method invite bids from an established group or an unlimited number of suppliers respectively. In an attempt to open up government procurement to foreign companies the GATT agreement allows single tendering in only five special cases (Paterson 1986, p. 148).

Secondly, domestic suppliers can no longer be favoured under the conditions of participation. Discriminatory procedures, such as financial guarantees to selective domestic suppliers can no longer be implemented without extending guarantees to foreign suppliers as well. The period for submitting a bid must be adequate and the national government must ensure that tender documentation contains all the necessary information to allow suppliers to submit tenders (Paterson 1986, p. 148).

In practice, however, this agreement appears not to have opened up government procurement to foreign companies and there are no indications that the agreement has noticeably altered trade patterns. The feeling persists that governments still buy from domestic suppliers even if their costs are higher than the prices of imported products. Several aspects of the GATT code have limited its effectiveness.

- The code applies only to contracts over SDR 150,000 (Special Drawing Rights) or about \$220,000 Canadian (*Review of Canadian Trade Policy*, 1983, p. 142). In theory, this does not allow a government to break up a larger purchase into components small enough to be under the limit (Graham 1983, p. 359). In practice, however, this method of circumventing the code is difficult, if not impossible, to control.
- The code does not apply to service contracts, construction contracts, or national security items (Graham 1983, p. 360). The exclusions account for a large portion of government purchases.
- The code applies only to central governments, not to state, provincial, or municipal governments (Graham 1983, p. 361).
- The code does not apply to the semi-autonomous government agencies that in many countries own and operate

telecommunications systems, hydro systems, and transportation systems (Graham 1983, p. 360).

- The code permits the maintenance of domestic preferences where a new product has been developed as part of a government-assisted R&D program.
- The code exempts purchases required with extreme urgency and purchases which should be compatible technically with existing installations.

The GATT Procurement Code should be understood in the context of the earlier quotations from McAfee and McMillan. Any government can use informal practices to avoid its obligations under the code (Graham 1983, p. 356-57). Any government can claim that a particular contract has special considerations that warrant an exemption. Furthermore, conscious manipulation of bidding provisions can exclude foreign competitors.

Conclusion

The experiences of the GATT Procurement Code are useful when considering the probability of success in future international negotiations on this subject. One has to be pessimistic about the ability to enforce such agreements. Regardless of the intent of those who negotiate and sign a procurement code, public servants and politicians seem able to avoid the provisions of an agreement quite easily.

Governments today are responsible for enforcing a host of regulations, from product safety to environmental protection. Apart from the loopholes and means of avoidance discussed above, governments could use these product standard regulations to justify future domestic preferences in their procurement practices, which means there is substantial scope for developing rationales to justify future domestic preferences.

Chapter XI

Regulations

Introduction

Recent decades have seen a proliferation of regulations at all government levels in all countries. Many of the regulations have altered international flows of trade and investment, and have become important instruments of government industrial strategy. For the information technology sector, regulations have become major determinants of trade and investment. The design and enforcement of appropriate domestic regulations will continue to be of central concern for Canada. They will have to be developed in the context of future international agreements seeking to create freer trade by placing limits on domestic regulations.

Some regulations have been designed specifically to provide domestic corporations with economic advantages over foreign corporations. Others, such as Canada's Foreign Investment Review Agency (FIRA), were created to prevent certain kinds of foreign investment. Even when FIRA did approve foreign investments, it often compelled foreign investors to buy their materials in Canada instead of importing them. FIRA also pressured foreign multinational corporations to conduct research and development (R&D) within Canada rather than abroad. Many other regulations have sought to restrict the economic activities of foreign firms. Until recently, for example, Canadian banking legislation severely limited the activities of foreign banks.

Maintenance of national economic independence and cultural sovereignty have been central objectives of such regulations. From this perspective, many nations regard the telecommunications sector as a key element in their future economic development. The creation of an appropriate network and an appropriate rate structure are therefore seen as matters of public policy, requiring government involvement.

Other regulations may also have an impact on international trade and investment even if their principal objective lies elsewhere. Governments have developed complex product standards ostensibly in the interest of customer safety or of product compatibility. Yet these can be used to keep out foreign products because foreign standards are not appropriate. For Canada, the regulations concerning telecommunications equipment have clearly affected trade patterns.

Governments may feel a responsibility to protect the privacy of their citizens. They may feel that they can do so only if personal information is retained within the geographical area that they control. Transborder data flows may destroy their ability to protect their citizens' privacy. Hence governments may impose regulations that restrict the economic activities of foreign companies insofar as those activities depend on transborder data flows.

Faced with this large and growing body of regulations, many foreign companies may feel that they must build a subsidiary in each of their principal markets to be able to sell there. To be aware of changing local regulations and to gain the preferences accorded local firms, the multinational may be forced to develop a significant presence in many countries. The extent and complexity of regulations means that minimization of production costs is no longer the sole criterion for plant location.

When considering the impact of regulations on future investment and trade patterns, it is necessary to compare the regulatory environment of North America, Europe, and a few of the other economically advanced nations with the regulatory environment of many less developed countries (LDCs). On the one hand, the LDCs may offer an extremely low-wage labour force which could attract future multinational investment. Yet the volatility of the regulatory environment may prevent the investment flows that the economic criteria could justify. The risks of nationalization, foreign debt repudiation, and unforeseen inflationary and foreign exchange rate movements—all these may tend increasingly to shift investment into relatively secure nations in spite of the wage differentials that favour offshore production.

FIRA and Investment Canada

From 1974 until 1985, FIRA screened investment by foreign firms and attempted to maximize the benefits Canada would gain from foreign investment. FIRA's objectives and processes provide an informative case study of regulations directed specifically at foreign firms. Its problems and inconsistencies—and the difficulties experienced by foreign firms—are found in other countries with similar regulations, and they will probably reappear to some degree under its successor, Investment Canada.

In examining investment proposals, FIRA staff prepared extremely detailed analyses, based on consultations with federal departments, provincial ministries, representatives of the firms involved, and other interested parties, and focused on "significant benefit to Canada."

The factors involved in assessing "significant benefit to Canada" were laid out in section 2(2) of the Foreign Investment Review Act:

- a) the effect of the acquisition or establishment on the level and nature of economic activity in Canada, including, without limiting the generality of the foregoing, the effect on employment, on resource processing, on the utilization of parts, components and services produced in Canada, and on exports from Canada;
- b) the degree and significance of participation by Canadians in the business enterprise or new business and in any industry or industries in Canada of which the business enterprise or new business forms or would form a part;
- c) the effect of the acquisition or establishment on productivity, industrial efficiency, technological development, product innovation and product variety in Canada;
- d) the effect of the acquisition or establishment on competition within any industry or industries in Canada; and
- e) the compatibility of the acquisition or establishment with national industrial and economic policies, taking into consideration industrial and economic policy objectives enunciated by the government or

legislature of any province likely to be significantly affected by the acquisition or establishment.

Each year FIRA published an annual review. In the reviews it listed 10 categories of benefits, based on the criteria listed above, and listed the categories in which each particular investment proposal was expected to provide significant benefit to Canada. These categories were: increased employment; new investment; increased resource processing or use of Canadian parts and services; additional exports; Canadian participation (as shareholders/directors/managers); improved productivity and industrial efficiency; enhanced technological development; improved product variety and innovation; beneficial impact on competition; and compatibility with industrial and economic policies. The analyses compiled by FIRA were based on this approach.

In addition to examining investment proposals and soliciting opinions from other government departments, FIRA also took an active role in negotiating with applicants in order to improve the benefits Canada would receive from their proposals. The negotiation procedure was sometimes lengthy and may have involved any element of the business's operations. The above list of benefits seems to have formed the agenda for the negotiations. The evaluation of each proposal included any undertaking to which the applicant had agreed. The Act provided for the obtaining of court orders to enforce undertakings; it also provided for the citing and punishment of those who failed to obey such court orders.

A recent study by Duncan McDowall (1984) published by the Conference Board of Canada, *A Fit Place for Foreign Investment: Foreign Investors' Perceptions of Canada in a Changing World*, surveyed both actual and potential foreign investors in an attempt to identify factors that either attracted or deterred investors in deciding on projects in Canada. The survey attempted, in the words of the author, to reach

not just . . . investors with a proven interest in Canadian investment but also those who had considered Canada but had never proceeded with their investment plans. . . The questionnaire was mailed during June and July 1983, to a sample group of companies structured to reflect the overall historical patterns of investment flowing into Canada, according to nation of origin and primary economic activity. (McDowall 1984, p. 1)

The survey focused on investors' views of Canada over the last 10 years and found that most potential investors consider Canada to have

an attractive investment climate. However, the study also found that "a minority of potential investors, 11 per cent of the respondents [31 firms of 278], ... had been deterred from investing in Canada by the existence of various forms of foreign investment controls" (p. ix). Further, "[t]hose companies and individuals citing government regulation and foreign investment controls as the "most important" factor in the analysis of their Canadian investment prospects formed a small but vocal minority ... FIRA was criticized for the principles underlying it and for its bureaucratic operation" (p. x).

In considering FIRA's processes, a serious concern is that similar applicants may not have necessarily received similar treatment. Because FIRA's deliberations were conducted in secrecy, and information pertaining to resolved cases was not available to provide guidelines for other applicants, a high degree of uncertainty was introduced into the investment and investment-related decisions of both foreign and Canadian firms.

No public documentation exists concerning FIRA's pursuit of approved cases to ascertain that undertakings given by firms during review were actually carried out. Not one firm was prosecuted for failing to fulfill its undertakings, even though the Act gave FIRA the power to do so. The absence of prosecutions does not prove lack of enforcement; it only raises the suspicion. However, it may have tempted applicants to make promises in bad faith simply to gain approval. Consequently, the honest applicant may have been put to a disadvantage.

The political nature of the process added to this concern about inconsistency. FIRA's decisions changed as economic and political circumstances changed. Consequently, the timing of one's application could have made a major difference in the outcome.

Many other nations have regulatory mechanisms to screen foreign investment. A recent study by Safarian (1985) provides a detailed look at the policies of 13 countries. Safarian finds four basic policies on the treatment of MNEs. These are: (1) excluding certain sectors for investments by such companies, (2) setting rules to control the basis for their establishment and subsequent expansion, (3) offering incentives for their establishment, often in return for agreement to perform in certain ways, and (4) treating established foreign-owned firms less favourably than domestically-owned firms (p. v).

Safarian analyzes the policies of the 13 countries using these four categories. He discusses the underlying national concerns about foreign direct investment (FDI) and analyzes the degree to which regulatory policies fall short of achieving their stated objectives. His recommendation for the future is for countries to avoid unilateral moves and to negotiate multilateral agreements, possibly through

GATT or the Organization for Economic Cooperation and Development (OECD) (Safarian 1985, p. 92). A recent study by David Anderson (1984), *Foreign Investment Control in the Canadian Mineral Sector: Lessons from the Australian Experience*, contrasts the Canadian and Australian approaches to regulating FDI, specifically in the non-petroleum mining sector. Anderson presents a strong case that Canadians should learn from the Australian approach, particularly for the following reason: "The Australian regulatory apparatus has been largely accepted by the relevant national and international interest groups. In contrast, the Canadian Foreign Investment Review Act and . . . FIRA [have] been the source of widespread domestic and external criticism" (p. xiii). Insights gained from studying the Australian regulation of the mineral sector point towards a third alternative to FIRA for regulating foreign investment in Canada.

The Australian system, in place since 1976, concentrates on the degree of foreign ownership. Each new mining project must normally have at least 50 per cent Australian ownership (75 per cent for uranium projects) in order to be approved by the Foreign Investment Review Board (FIRB). There is a "naturalization process," introduced in 1978 (Anderson, p. 96), which, as Anderson explains, grants to companies whose actual level of Australian ownership may be as low as 25 per cent, prior credit for having 51 per cent Australian ownership (p. 96). "In return, they publicly agree to move towards the 51 per cent target and to ensure that a majority of the voting members on their Board of Directors are Australian citizens" (p. 96). Approval must be obtained for each new mining project involving a total investment of A\$5 million or more or takeover by a foreign firm of a firm with more than A\$2 million of assets (p. 77).

Like the Canadian system, the Australian system screens FDI in general to ascertain that the proposed investments are not contrary to the national interest (p. 122-123). However, the Australian system focuses the regulators' attention on the degree of foreign ownership. In fact, in the mineral sector the Australian approach "is virtually to ignore the national benefits test associated with the general screening mechanism. Instead, it relies on a sector-specific quantifiable test" (p. 123). The "not contrary to the national interest" condition and the 50 per cent (or 75 per cent for uranium) Australian equity condition must both be met for a project to be approved, with the latter dominating in practice (pp. 123-124). Thus, in the mining sector the Australians in effect use a "fixed rule" approach. Some features make this an appealing model for Canada. Anderson notes that such an ownership requirement for FDI should "reduce the decision time, virtually eliminate the uncertainty faced by proponents, and largely preclude the need to negotiate innumerable performance undertakings" (p. 4).

On July 2, 1985, the Investment Canada Act replaced the Foreign Investment Review Act. The Foreign Investment Review Agency was replaced by Investment Canada. The purpose of the Investment Canada Act is set out in Section 2 of the Act:

Recognizing that increased capital and technology would benefit Canada, the purpose of this Act is to encourage investments in Canada by Canadians and non-Canadians that contribute to economic growth and employment opportunities and to provide for the review of significant investments in Canada by non-Canadians in order to ensure such benefit by Canada.

Investment Canada will continue to monitor foreign investment in Canada. A major focus will continue to be the maintenance of cultural sovereignty. Preservation of economic independence will also continue as a central objective and will be achieved through screening of all large takeovers. On the surface, one may note that if Investment Canada had been in place in 1984, the total number of investments subject to review would have been reduced by 92 per cent. It is essential to realize, however, that almost 75 per cent of the asset values would still have been reviewed (*Globe and Mail* July 8, 1985, p. B1-2). This means that the review process continues to be of importance for foreign firms considering significant investments.

In 1983-1984, the United States instituted legal action under GATT against the sourcing requirements of the FIRA process. GATT ruled that these requirements were inappropriate; they compelled the foreign investor to buy from local suppliers, placing foreign suppliers at an unfair competitive disadvantage. Nevertheless, it is likely that informal government pressure will continue to influence the sourcing decisions of foreign firms.

The death of FIRA has not eliminated the underlying Canadian political objectives. We may expect that the issues discussed above will reappear in Canada as well as in many other countries. Corporations will have to learn how best to cope with such regulations.

Generally, the manufacturers of business equipment did not experience the degree of difficulties with FIRA that other sectors did. A key criterion for FIRA was the effect of the foreign investment on productivity and efficiency. Here the business equipment manufacturers ranked very high. This fortunate position may become vulnerable, however, if such corporations shift into the telecommunications sector or the business consulting-services sector.

Regulation of Telecommunications and Transborder Data Flows

Throughout the world, governments have increasingly been stepping into the telecommunications sector. A list of recent regulatory interventions has been compiled by U.S. Senator Robert Packwood (1983). These include the targeting of telecommunications for special government assistance; various regulations to protect the privacy of information; tax provisions that treat foreign and domestic firms differently; the licensing of personnel; rules concerning satellites and the leasing of communication channels; equipment standards; use of government owned corporations to conduct certain types of activities; and international provisions to enhance the capability of LDCs in this sector. Regulatory interventions have been motivated by many objectives, among which the following seem to be most significant:

1. Enhancement of Culture and Cultural Sovereignty

The content of telecommunications systems often involves motion pictures, political commentary, and news broadcasts. Each of these can be seen as integral elements of a nation's self-identity. To depend entirely on foreign production and transmission of such programs would be to surrender important decisions about content, interpretation, and scheduling. Foreign perspectives on these decisions could be quite different from the perspectives of domestic nationals. Consequently, foreign ownership and operation of telecommunications systems could seriously alter the individual citizen's view of the world and his or her nation's place in it. Canadian politicians have certainly expressed this concern and have instituted regulations to deal with this.

Canadian sovereignty in the next generation will depend heavily on telecommunications. If we wish to have an independent culture, then we will have to continue to express it through radio and television. If we wish to control our economy then we will require a sophisticated telecommunications sector developed and owned in Canada to meet specific Canadian requirements. To maintain our Canadian identity and independence we must ensure an adequate measure of control over data banks, transborder data flow, and the content of information services available in Canada. If we wish to build a Canadian presence in world industrial markets then we will be required to encourage the growth of Canadian telecommunications industries that will be competitive in world terms.

In approaching telecommunications we should realize that its importance demands we view it in a special way. Telecommunications, as the foundation of the future society, cannot always be left to the vagaries of the market; principles that we might care to assert in other fields, such as totally free competition, may not be applicable in this crucial sphere. We must look at it freshly, without preconceived ideas (*Telecommunications and Canada* 1979, p. 2).

Since the telecommunications sector is becoming an ever greater influence in shaping the attitudes and wishes of citizens, we may expect that governments will continually search for new ways to regulate it. These regulations will go beyond a discrimination against foreign corporations. They will include, for example, the setting of rate structures so as to ensure widespread access. Cross-subsidization may be required in rate structures so that remote geographical areas and low-income families can participate. Programs with domestic content or dealing with particular subjects may be subsidized to ensure that citizens have access to them.

The range for such government intervention seems unlimited. Corporations will have to adjust as public policies change. This situation places a substantial value on active corporate involvement to prevent regulatory changes that will fail to meet their objectives.

2. *Provision of Domestic Employment*

The advent of multinational enterprises and their increasing rationalization of production processes, brought about by advances in information technology, may retard the process of job creation in the host country. These concerns have been expressed by Shirley Serafini and Michel Andrieu in their book, *The Information Revolution and its Implications for Canada*.

The information revolution may accelerate the erosion of national sovereignty by further increasing the dominance of multinational corporations in the world economy . . . As a result . . . host countries may experience a serious loss of control over domestic economic activities. The increased importance of multinationals could mean that a larger share of the Canadian economy will be run from abroad. The migration of control to headquarters could cause further reductions in the autonomy of branch plants. Countries such as Canada might evolve from a branch plant economy to a "warehouse economy." In such an economy,

branch plants would have lost to headquarters, not only jobs, but also important decision-making functions in such key areas as financial control, administration, research and development, planning and marketing (Serafini and Andrieu 1980, p. 28).

Faced with such concerns about domestic employment, governments have instituted a variety of regulations. For purchases of hardware, regulations may specify particular product standards that effectively exclude imported equipment which is built in accordance with different foreign standards. Canada's telecommunications industry, for example, is regulated in important aspects by each provincial government (Buchan and Johnston 1982). Over the years, different regulations have been put in place by each province, as Table 11.1 indicates. These differences in standards and differences in rules concerning processes and products for connections mean that local provincial firms have a significant advantage in bidding for contracts. In this respect, even Canada lacks an economic union or common market.

Regulations that favour domestic production may create local jobs, apart from the cultural considerations discussed above. From this perspective, the creation of an indigenous network of radio, television, and movie companies may be seen as providing a mechanism for the cultivation of local talent. As the service sector grows in size and as a higher proportion of jobs are to be found in the telecommunications sector, this issue of employment will become increasingly important.

Advances in telecommunications technology are permitting corporations to locate larger segments of their operations anywhere in the world. Customer records and processes of data manipulation can now be accessed across thousands of miles. Inventory control systems can also be monitored far from the actual business operation. A multinational can use telecommunications technology to shift jobs from one country to another (Serafini and Andrieu 1980, p. 28). One might expect governments to react to this possibility with new regulations that protect domestic employment.

3. Protection of Privacy

To some degree, regulations restricting transborder data flows may be seen in the context of the domestic employment issues discussed above. Yet privacy has recently become a real issue, and many nations have imposed legislation with the objective of protecting the individual rights of their citizens.

Table 11.1
Telecommunications in Canada

Company	Ownership	Regulatory Body
Alberta Government Telephones	Provincial Crown Corporation	Public Utilities Board of Alberta
B.C. Tel	Investor-Owned	CRTC
Bell Canada	Investor-Owned	CRTC
Island Tel, P.E.I.	Investor-Owned	Public Utilities Commission of P.E.I.
Manitoba Telephone System	Provincial Crown Corporation	Public Utilities Board of Manitoba
Maritime Tel & Tel	Investor-Owned	Board of Commissioners of Public Utilities of Nova Scotia
N.B. Tel	Investor-Owned	Board of Commissioners of Public Utilities of New Brunswick
Newfoundland Telephone	Investor-Owned	Board of Commissioners of Public Utilities of Newfoundland
Saskatchewan Telecommunications	Provincial Crown Corporation	Lieutenant Governor in Council
Telesat Canada	Government of Canada and the Regulated Canadian Carriers	CRTC

Source: Buchan *et al.* *Telecommunications Regulation and the Canadian Constitution*. 1982.

The growth of high technology and the potential for abuse of the vast amounts of personal information being collected in all sectors of society, public and private, is creating a growing awareness of the need for some form of laws to protect the privacy of the individual. Such a movement is becoming well entrenched in some European countries where many data protection (or protection of personal information) laws as they are called, are on the statute books. [In fact] some European laws require a licence, issued by a data regulatory agency, to send personal data to another country. If a country to which personal information is being sent does not have similar protective legislative measures, this could be a factor in denying an export licence (Riley 1984, p. 7).

A recent book by Helena Stalson (1985) describes this worldwide development:

In 1974, the United States passed the Privacy Act to give its citizens access to information in government files. A few years later, Canada, New Zealand and seven European countries, including France and Germany, passed legislation protecting the privacy of individuals and in some cases corporate entities. In 1980, the OECD issued non-binding guidelines of data protection measures, directed at individuals, not legal entities, and 180 U.S. corporations endorsed the guidelines and said that they were conforming to them. In 1981, the Council of Europe's 21 member governments signed a convention similar in many ways to the OECD guidelines but calling for binding application of its principles. Since then, most international firms appear to have learned to live with privacy regulations. Problems seem to have arisen chiefly for financial institutions, which have accumulated large quantities of data on the personal lives and credit worthiness of individuals and institutions, but they too have accommodated to national regulations and in most cases have adopted even more rigorous security and confidentiality requirements (Stalson 1985, p.74).

These issues are likely to become more important. Business systems are being linked more and more with operations in other cities and in other countries. Direct communications with customers, warehouses, and other branches of the same company are becoming increasingly important. Costs of selling and warehousing can be reduced, time can

be saved, and product modifications can be made easier. The line between business equipment and telecommunications equipment is disappearing.

We can expect to see many attempts to reduce the cost of long distance transmission of data and printed materials. In many cases, these technological advances will probably conflict with current regulations and rate schedules. Consequently, the issues involved in regulatory changes will intensify in importance, requiring attention and leadership from business people as well as governments.

Conclusion

Governments have instituted a wide array of regulations as the means of pursuing several basic objectives, including the enhancement of culture and cultural sovereignty, the provision of domestic employment, and the protection of privacy. From this perspective, it is clear that governments will not surrender their regulations readily or easily. It is likely that current regulations, or similar future regulations, will continue to affect international trade and investment. For the information technology sector, regulations will remain important, particularly within the telecommunications industry. Attempts to negotiate their reduction will face substantial difficulties.

In view of the diversity of regulations and of enforcement procedures, bilateral negotiations may be less complicated than multilateral negotiations. It may be more realistic to hope for an agreement that exchanges bilateral concessions rather than an agreement that rests upon a mosaic of multilateral concessions. Yet even in the context of possible Canada-U.S. agreements, it is apparent that issues like cultural sovereignty are of major concern in spite of the many common elements of history and culture.



Chapter XII

Protection of Intellectual Property

Introduction

Today's emphasis on research and education as a new high-tech strategy means that the protection of intellectual property is becoming an increasingly important public policy issue. Advances in Canadian research and education depend on the advances in knowledge that have occurred elsewhere in the world. Therefore, their effectiveness can be limited by restrictions on the international transfer of those advances in knowledge. Conversely, the benefits that Canadians can gain from Canadian advances in knowledge depend on the protection that other nations extend to Canadian patents, trademarks, designs, copyright, and other industrial secrets. In view of this, the protection of intellectual property is an international issue requiring international agreements. Yet it is not clear what types of agreements may be in Canada's best interests.

This chapter discusses the new economic forces that bear on public policy in this area. It emphasizes that these forces are continually changing the answers that one might give to policy questions. The protection of intellectual property will remain at the centre of international trade negotiations for the foreseeable future. The optimal solutions are not obvious; they may differ from one nation to another; and they will no doubt change. This perspective was presented in 1986 by The Honourable Michel Côté as Canada's federal Minister of Consumer and Corporate Affairs:

As for intellectual property, it's on the agenda for many reasons. The answers to many of the world's problems are to be found in new technology. We all understand the need to have appropriate economic incentives to stimulate innovation. But we also recognize the need to spread the technical information resulting from innovation, in order to get new ideas and new products and processes into use, with as little delay as possible. Our interests are best served by pursuing both goals at the same time. But this does not happen automatically. The nations of the world are at different stages of economic development and have different views about intellectual property.

On the one hand, developing nations need access to innovation, and their priority is to acquire new technologies. Industrialized nations, on the other hand, owe a large share of their prosperity to innovation and want to receive a fair price for the technology they have developed. Obviously, there is some common ground, because continued access to technological innovation is unavoidably linked to its adequate protection and compensation. The only realistic approach, in my opinion, is to attempt to achieve a fair balance between the rights of innovators and the needs of users (Michel Coté 1986, p. 7).

Changing Parameters in the Protection of Intellectual Property

Intellectual property is being buffeted by at least three different kinds of changes. Each set of forces is so strong that each, in its own right, will shape the development of our information economy. First, the nature and content of intellectual property have been changing in several important respects, including new mechanisms for reproduction and transmission, greater collaboration among many individuals and groups, and wider applicability of many ideas and processes. These have complicated the development of appropriate legislation. Second, public funds are playing an increasing role in financing research and development, complicating the division of ownership between private interests and society as a whole. Third, the world economy has become more closely integrated, with the result that the creation of intellectual property in one country may be readily copied in other nations. Consequently, no society by itself can protect intellectual property. Rather, the protection of intellectual property can be achieved only through international agreements.

The interactions among these somewhat independent sets of changes must not be overlooked. To examine each separately is to

miss extremely important insights. To institute public policies solely from each perspective separately is to create regulations and incentives which may conflict with each other. Rather, public policies concerning ownership must be based on an all-encompassing view of the developing information economy.

The Changing Nature and Content of Intellectual Property

In April 1986 the U.S. Office of Technology Assessment (OTA) issued a report entitled, "Intellectual Property Rights in an Age of Electronics and Information." This volume clearly describes and summarizes recent changes in the nature and content of information itself.

The changes that new technologies are making in the way that information is created, distributed, and used today are as fundamental as the changes made by the printing press. These changes are undermining many of the mechanisms by which the U.S. intellectual property system has operated in the past. . . .

Originally, the implementation of intellectual property law, and particularly copyright law, was relatively simple. The Government granted copyrights to authors and patents to inventors. Rewards were determined in the marketplace. The patent and copyright holders, themselves, monitored infringements and enforced their rights through the courts. Individuals' interests coincided with the public's interest—to profit from copyright, an author had to print his works and sell them; to profit from a patent, the inventor had to disclose his ideas to the public.

Today, technological change is complicating the intellectual property system (United States, OTA Report Brief p. 1).

The OTA report describes particular aspects of what we might refer to as changes in the "technology of information" itself.

Today, original work may be the result of collaboration among many individuals who live in many countries. Existing legislation, based on the concept of single authors or inventors in a single country, may no longer be appropriate (United States, OTA Report Brief p. 68-69).

Today, science is creating many new types of materials. Original work can often be copied using alternative materials. People who

drafted legislation even a few years ago did not foresee the extent of this substitution possibility.

Mechanisms for reproducing original work have become more sophisticated and readily available. The printed word, the motion picture, and computer software – all can be copied easily and cheaply without the knowledge of those who created them (OTA p. 100-103). "Pirating" results in commercial sales that deprive the creator of royalty payments, and they may also directly reduce the sales and profits of the legitimate distributor. Television programs can be accessed by satellite and cable in ways that deprive the rightful owners of control, sales, and profits. Domestic laws concerning such "theft" are difficult to enforce. The ease of transborder electronic communication means that all nations can be affected by activities of this type anywhere in the world. The failure of one government to police these activities can affect all other nations. An April 1986 statement by the Office of the U.S. Trade Representative emphasizes the significance of the policing issue.

Piracy thrives even in some countries that have nominally good laws. The causes are simple: inadequate penalties that have no meaningful deterrent effect and a lack of government commitments to enforcing the rights guaranteed by law. This problem is particularly acute for such industries as motion pictures, sound recordings and software. Such industries lose hundreds of millions of dollars annually to pirates whose actions, if not encouraged or condoned, are at least not adequately penalized by their governments (United States, Department of Commerce 1985, p. 3).

In 1985, a U.S. Council Task Force on Intellectual Property estimated that U.S. companies lose \$8 billion in sales annually due to this international piracy (U.S. Council Task Force on Intellectual Property 1985, p.6).

In this situation, where the creator cannot obtain all the commercial benefits arising from its intellectual advance, the incentive to innovate is clearly being hurt. Future research and development will be retarded.

The main economic rationale for intellectual property protection is to increase the rate of production of intellectual works. In the absence of such protection, any enterprising individual could simply obtain a copy of the work and proceed to manufacture and distribute it to the buying public. Since he would not have to incur the initial

costs involved in inventing or creating the work, he could market it at a lower price than the original inventor or creator could. Consequently, the economic incentive to produce intellectual property material would fall. Intellectual property protection is an attempt to overcome this problem (Keon 1986, p. 29).

For both education and entertainment, the individual has greatly expanded his or her desire to own more information in its various forms. The division between reproduction for personal use and reproduction for commercial sale is introducing a new area of difficulty for legislators (United States, OTA pp. 193-201).

Information is taking new forms that do not automatically fit into existing legal categories. Computer software may be the most dramatic example (Schuyler p. 122). However, it is probably fair to say that the design characteristics of many of today's products may not be readily described in ways that are able to exclude substitutes. Yet with rising incomes and new varieties of products, design characteristics are becoming increasingly important. Specially designed clothing and leather products, for example, are presenting new problems for existing legislation. New manufacturing processes often share this difficulty.

It seems that a growing number of original ideas can find multiple uses in today's economy. Often these uses extend far beyond anything dreamt of by the creator. Where should legislation draw the ownership line in terms of additional uses?

Increasingly, new kinds of information are playing a new role in the educational process. In order to train and retrain people adequately for our information economy, educational institutions need access to patented or copyrighted materials and equipment. Charging royalties and licence fees may place the cost for some information beyond the budgetary reach of educational institutions. From the perspective of society as a whole, this may be undesirable.

New technologies can misrepresent or distort original work in ways that are unfair to the intent of the author or inventor. What rights should the author or inventor have over such situations?

The OTA Report emphasizes the difficulties in designing and enforcing appropriate legislation, and it notes that inadequate protection will reduce the private incentive to create and disseminate new ideas and processes.

Information technologies are impeding traditional enforcement mechanisms. They make the copy, transfer, and transformation of works cheaper, faster and more private, and thus more prevalent and harder to detect and

prove. Without effective enforcements of their rights, intellectual property owners may have less incentive to produce and disseminate intellectual works. This, in turn, could jeopardize the benefits society gains from the open dissemination of intellectual works. And, insofar as there are widespread, unimpeded infringements, the legitimacy of intellectual property law might itself be undermined (United States, OTA 1986, p. 98).

Having examined this set of changes in the "technology of information," the U.S. Office of Technology Assessment emphasizes that legislative reforms will have to be a continuing process (OTA p. 295). Laws that are most appropriate today may become undesirable in the future, when the technology of information has been altered once again. This need for continual awareness and a constant readiness to modify established practices is an important theme when we shift our attention to two other sets of basic changes.

The Ownership of Publicly Funded Research

In Chapter XIII, we will consider the rationale for using public funds to pay for research and education. Society as a whole may gain from the research efforts of individuals and corporations and the latter may be unable to capture the financial value of these public benefits or externalities. Externalities created by a new product or process may increase the profitability of commercial customers and the satisfaction of the public as consumers. The society's rate of economic growth may be increased.

A potential user of a new product or process will not know with certainty the full value of its use, and so will not be able to offer a payment equal to that full value. This is a particularly difficult problem with new information that may be the basis for additional future advances in knowledge. How could one place a value on the original microchip, when one could not anticipate its usefulness in future innovations?

For some innovations the possibility of failure may entail too large a financial risk for an individual or corporation, while a society is able to pool these risks by funding a number of research projects. Practical market constraints on the issuance of stock and the borrowing of funds may limit private research to less than socially optimal levels.

For these and other reasons, a modern society should actively contribute to the funding of research by individuals and corporations. Chapters XIII and XV discuss the processes that Canadian

governments might use for this purpose, and they emphasize the synergism of the university-corporate-government nexus.

As we shall see, governments are developing programs to strengthen the linkages between academic research and the practical application of that research in economic activities (U.S. General Accounting Office 1983). Pennsylvania's "Ben Franklin Partnership" and Ohio's "Thomas Edison Program" are examples of active government involvement in fostering university-industry linkages and also practical application of new technology to business. Furthermore, university research and development (R&D) parks are springing up throughout the United States as industry and academia have begun to see the profitable arrangements that can be made. Recent budgets of the Canadian and Ontario governments also provide for new programs to achieve this objective.

With research and education as a Canadian high-tech policy, how should the financial gains from research be shared? In research projects that are funded by both corporations and publicly supported universities, what percentage of ensuing profits should go to the corporations and what percentage to the universities? Should each university be free to negotiate its own financial terms? Or should university involvement be directed by government with profits accruing to government or its central funding agencies?

We may reasonably speculate that each society's answers to these ownership problems will change over time. Economic circumstances will change. Our understanding of the costs and benefits of such joint activities may improve. And a society may alter its policy decisions as it comes to realize the extent to which it is collectively paying for the creation of knowledge that will be used in private commercial ventures.

The Increasing Integration of the World Information Economy

A third broad set of changes are those in flows of international trade and investment: the information economy is increasingly an international economy.

Over the years, much of the literature about intellectual property has neglected this international perspective (Cornish 1981), (Palmer and Resendes 1982). Economic theory in regard to intellectual property has often been presented as if only one society were involved. Today, we must realize that developments in other countries concerning the use of information, and the programs of other countries to support R&D, will have a direct impact on our own economic activities.

In the post-war period, Japan more than any other country has been able to copy the technological advances of the United States and Europe. Lower wage rates have combined with this copying of technology to shift the manufacture of many products from the U.S. and Europe to Japan. Multinational corporations have taken an active lead in technology transfer, creating subsidiaries "offshore" to take advantage of lower wage costs.

What is really important about this set of changes is that many newly industrialized countries (NICs) are in the same kinds of circumstances today as Japan was 25 years ago. Hong Kong, Singapore, South Korea, Brazil, Mexico—all these and others—have the capacity to copy the latest in technology and then sell the products into the North American and European markets. Recognition of this new offshore capability is essential when considering legislation that protects intellectual property. Increasingly, we will find that domestic legislation by itself can offer little protection. In terms of the public interest, domestic legislation may even be undesirable in that it may simply shove employment opportunities offshore to countries where the protection is not honoured.

Will international cooperation be a simple matter? The answer is clearly negative when you consider that the economic interest of many countries lies in the rejection of any protection for intellectual property. Why should these countries honour the property ownership of others when their own manufacturers can create jobs and prosperity through piracy and counterfeiting?

The first attempt at fostering international cooperation for the protection of intellectual property was the Berne Convention in 1886. Several succeeding international agreements with regard to this issue have followed. Yet despite these attempts there are still problems with piracy of intellectual property. In April 1986 the Reagan Administration announced that it was considering a new program to combat the piracy of American intellectual property. This program would give duty-free import privileges such as those found in the Caribbean Basin Initiative and the Generalized System of Preference to those countries that protect American patents, copyrights and trademarks (*New York Times* April 6, 1986). The administration is also hoping to "develop minimum standards of intellectual property protection within the General Agreement on Tariffs and Trade as part of a new round of trade liberalization" (*New York Times* April 6, 1986).

From this perspective, it is important to see ownership as a public concern rather than solely a private moral issue. International respect for the patents and copyrights of one's citizens is more than a matter of guaranteeing a fair personal financial reward for their research. It is also a matter of jobs in one's own country as opposed to jobs in other countries. Furthermore, to the degree that public funds

have paid for the relevant research, this is directly of financial concern to the donor government.

An additional complication arises from the process of international dispute resolution. Suppose that all countries were to sign an agreement to honour intellectual property in other nations. Violation of such an agreement could not be stopped quickly or easily. Today, a technological advance may offer a competitive advantage for only a few years; it may quickly be overtaken by other advances, or rendered obsolete by changing tastes. By the time an international dispute is resolved through a judicial process, the creator may have missed the opportunity to profit from his or her intellectual property.

Government programs of subsidies, loans, and tax concessions to support private R&D (Hollis 1985) have introduced additional elements to international relations. They can be seen as creating unfair competition, reducing private corporate costs below those of unsubsidized corporations in other nations. Trade flows can be distorted by these government financial programs. Government ownership can bring public high-tech policies directly into the determination of trade patterns.

Implementation of new technology often requires investments in new machinery and equipment. Public financial support extends beyond laboratories to include such investments. Innovation and entrepreneurship are now seen to be intimately linked with the creation of ideas and inventions.

In Canada, we could point to a host of government programs that assist private investment in R&D and equipment. We could also point to many government-owned high-tech manufacturers, such as Atomic Energy Canada Limited, and Ontario's former Urban Transportation Development Corporation Limited, which have competed internationally against private corporations.

Ron Wonnacott has written about this current tendency of governments to engineer a comparative advantage through the public financing of R&D (Wonnacott 1985). Attention is also turning to the competitive nature of this process. In some fields, the pursuit of new knowledge is becoming a contest among governments. Such sectors include the development of fifth-generation computers and new types of aircraft. An extreme example is the "space race" between the U.S. and the U.S.S.R. and the creation of a wide variety of new products as a result of it.

As a final element in the relationships between information and international relations, we should recognize the fears of many countries about relying on foreign multinational companies to obtain modern technology.

In a review of *Harry Johnson's Contributions to International Trade Theory*, Corden (1984, p. 581) has stated that "the much-cited

International Corporations paper is built around the idea that the primary function of the multinational enterprise is the generation and international transfer of productive knowledge. . . ." However, Corden quotes Johnson's warning that "it does not necessarily follow that recompense through monopoly profits on the use of knowledge is the ideal arrangement for the host country" (Corden 1984, p. 581). In his recent article on international trade, foreign investment, and the formation of the entrepreneurial class, Grossman (1984, pp. 605-614), has examined, by means of a theoretical model, how both trade and investment can have negative long-term effects on the development prospects of certain societies. Some Third World academics have decried the tendency of developing countries to rely on multinationals to increase development. These scholars claim that the country can become dependent upon the MNE and virtually cannot maintain its level of development on the basis of domestic entrepreneurship.

In Canada, there has been considerable debate about the disadvantages of relying on foreign direct investment as the vehicle for technology transfer. Many Canadians consider the entrepreneurial achievements of domestically located, foreign-owned firms. Because of these differences, it is argued that Canada will receive greater economic benefits from the latter than it will from the former. Canadians who share this view advocate public policies to stimulate the entrepreneurship of Canadian-owned firms, rather than foreign multinationals (Britton and Gilmour 1978), and may also advocate severe restrictions on foreign rights of establishment in Canada, as discussed in Chapter XI.

The April 1986 report of the United States Office of Technology Assessment reached a conclusion that is no doubt valid for all countries:

Our understanding of how the system now operates is extremely limited and technology is still changing. It is bringing new parties into the intellectual property debate and making information a critical factor for the economy and for society as a whole. Not surprisingly, the decisions that Congress makes about intellectual property policy will affect a broad range of other policy areas: communications, trade and international affairs, privacy, antitrust, education, public information, research and development, and tax policy. In making decisions about intellectual property policy, therefore, Congress will need to take into account new issues and new stakeholders and assure the coordination of policy making among diverse policy areas. (United States, OTA Report Brief 1986, p. 1)

Canadian Protection of Intellectual Property: The Legal Structure

In 1986, The Honourable Michel Côté presented the philosophy underlying current Canadian practices:

First of all, certainty is essential to a good business climate. Firms need to know what the ground rules are, what can be sold at home and abroad and under what conditions. Trade marks, for example, provide invaluable product identification. We could ask ourselves: What would have been the chances of McDonald's opening a franchise in China without the world-wide recognition of its name and logo?

Business also needs to be able to trade with the certainty that technology developed at great effort and expense will be protected by foreign and domestic patent laws. It needs guarantees that trade marks will not be used without permission by a foreign manufacturer producing inferior goods that are then sold at predatory prices.

Canadian industry needs know-how and technological inputs in order to achieve the level of efficiency required to compete successfully in world markets today. We are realistic: Canada is dependent on such inputs because, like most other nations, it cannot generate all, or even a major portion, of the technology it needs from domestic sources. It must necessarily rely on a good patent system as a window on the technological world.

Canada, therefore, has good domestic reasons for protecting intellectual property by enacting adequate legislation. It recognizes that such protection provides a necessary incentive to creative activities. Further, because of the protection which Canadian creators enjoy in large foreign markets, Canada has an interest in ensuring that the international intellectual property regime works effectively. There is no doubt, in our view, that sound multilateral arrangements for the protection of intellectual property will foster both certainty and trade (Michel Côté, 1986, p. 8).

This philosophy is implemented through five types of legislation which are described in the following excerpts from an article by Jim Keon (1986).

1. Patents

A patent... describes an invention and creates a legal situation in which the patented invention can only be exploited (made, used, sold, imported) with the authorization of the patentee. In Canada, the term of patent protection is 17 years. For an invention to be patentable, it must be new, that is, it has not been known or used before; it must be non-obvious, that is, any specialist in the same field would not have come up with the same solution; and it must be immediately applicable in industry, that is, it can be manufactured or sold.

2. Trademarks

A trademark is a sign that serves to distinguish the goods of an industrial or commercial enterprise or group of such enterprises from those of others. No one other than the owner of the trademark may use it or any similar mark that would lead to confusion in the mind of the public. The protection for a trademark is generally not limited in time, provided that its use continues.

3. Industrial Designs

An industrial design law gives protection to designers of ornamental aspects of useful articles.... To be eligible for protection, industrial designs must be original or novel and must be registered. Protection means that it may not be copied or imitated without the owner's authorization. The term of protection lasts up to 10 years.

4. Copyrights

A copyright is the protection given to authors and creators of cultural and informational products such as books, records, films, and works of art against a variety of unauthorized uses (for example, reproduction or public performance of a musical work). Unlike patents, copyright does not prevent others from using or copying ideas embodied in the work; protection goes only to the form or expression of those ideas. Moreover, independent creation of the same or a similar work is not prohibited as long as there is no direct copying involved (for example, many authors may write analyses of the last federal election without infringing each other's copyright). There are no requirements to register a work to make it eligible for protection; protection arises automatically upon the creation of the work and generally lasts for the life of the author and 50 years thereafter.

5. *Trade Secrets*

In addition to these forms of statutory protection, there exists common law protection for trade secrets in respect to confidential commercially valuable information. Obligations of trade secrecy can apply to concepts, ideas, test results, factual information, etc. They arise when the information is treated in a confidential fashion by its owner and there is an appropriate relationship of trust with the alleged infringer (Keon 1986, p. 28-29).

The creator of intellectual property can register his or her ownership under whichever category is most appropriate. International agreements rest upon the concept of "national treatment." National treatment means that citizens of other national signatories can register their ownership in Canada just as if they were citizens of Canada. For example, by signing the Paris Convention, Canada has promised national treatment for patent, design, and trademark laws to the citizens of all other signatories. By signing the Universal Copyright Convention, Canada has promised national treatment under copyright laws to the citizens of all signatories of that Convention. Canada has also signed the Berne Copyright Convention. Participation in the agreements has varied. The United States, for example, has not signed the Berne Convention.

The Implications of Information Technology for Changes in Copyright Laws

In Part A of this volume, we discussed significant alterations in the nature of the information technology industry. The diminution in the role of hardware and the increase in the role of software have meant that patents, trademarks and industrial designs can no longer offer adequate or appropriate protection. Rather, originators must look to copyrights and trade secrets as the means of protecting new software as intellectual property. In most countries, this shift has occurred slowly and only now is legislation concerning copyright receiving close scrutiny from the perspective of information technology.

Computer software has been accepted as a work of authorship in the United States since 1964, and this was clarified in 1980 under Title 17 of the United States Code. As Keplinger (1986) states, "the United States has led the growing consensus on the copyright-ability of computer software . . . and confirmation of the international consensus on copyright protection at a recent World Intellectual Property Organization meeting of experts apparently convinced the Japanese that copyright protection of computer software is the correct path" (p. 60). Japan, as well as the United Kingdom, Australia, India,

Hungary, France, the Federal Republic of Germany, the Philippines and Taiwan have also amended their copyright laws to specifically include software as a protected work. Court decisions in these jurisdictions have reaffirmed this position.

At this point in time, Canada is in the process of revising its legislation concerning copyright. A 1985 House of Commons Sub-Committee Report, *A Charter of Rights for Creators*, emphasized the need for legislative change.

If there is one area of creative activity where technological development has overtaken the 1924 Copyright Act it is in the vast domain of the computer. Computers have become a factor as a support for creative works, as an instrument in the creative process itself and as an occasion for an entirely new type of work: the computer program. Some are even of the opinion that, if not the computer itself, at least the microchip, should be regarded as a truly creative work and perhaps made into a new category of work protected by copyright.

The computer has taught us to translate all kinds of information into a digital form — not only numbers, but also words, musical notes, sounds and images. Anything can be expressed in the binary code. Information in such a form can be stored on various recording devices, reproduced, electronically transmitted, and transformed in various ways. This technological leap is as important as the Gutenberg printing revolution because it opens up even wider possibilities, only some of which are now known and fewer still currently exploited. The computer age has placed copyright principles themselves in a radically new environment with unpredictable consequences. One of the biggest challenges facing the Sub-Committee is to apply principles of intellectual property to this new environment. For a new Copyright Act not to address these questions would be to guarantee a slow erosion of the very concept of intellectual property (p. 39).

In 12 specific recommendations, numbered 52 to 63 inclusive, the House of Commons Sub-Committee advocated the following:

52. A new right to input any protected work into a computer should be provided in the revised law.
53. There should be no right of display in the revised law.

54. Fixation should be defined as all means capable of capturing a work, including capture in computer media, but excluding capture in a medium as volatile as a computer's main storage or display screen.
55. With respect to the right of reproduction, a material form should be one that has a certain degree of permanence.
56. Where a work created with the assistance of a computer is original the copyright in that work should be owned by the person responsible for its making and not by the owner of the copyright in the original program.
57. Ownership in compilations produced by computer data storage and retrieval systems should be vested in the individual or entity primarily responsible for the arrangements undertaken for making the compilation.
58. Computer programs should be protected by the revised law as a separate category of subject matter with the full regime of protection on the basis of reciprocity.
59. The Act should provide an exception to the right of reproduction to permit the making of a back-up copy.
60. The term of protection for computer programs should be the life of the author plus 50 years.
61. The government should study the possibility of providing an exception to permit the reproduction of a substantial part of a pre-existing program as a non-substantial part of another program.
62. Mask works fixed in semi-conductor chips should be protected by new legislation outside the *Copyright Act*.
63. The mask works to be protected are series of related images that represent the three-dimensional pattern of circuits and components fixed in a semi-conductor chip (pp. 41-47).

In February 1986, the Government of Canada released its official response to the Sub-Committee report. The document, *Government Response to the Report of the Sub-Committee on the Revision of Copyright*, listed the following reactions to the above twelve recommendations.

The government agrees with these recommendations in principle.

The issue of the right of display mentioned in recommendation 53, however, will be studied in further detail.

Recommendation 54 will be considered when defining the concept of fixation.

With regard to recommendation 58, the government agrees in principle that computer programs should benefit from the full regime of protection. However, it will give national treatment to foreign computer programs.

The government has studied the possibility of providing the exception suggested in recommendation 61 but has decided against it.

Finally, mask works fixed in semi-conductor chips will be protected in the *Copyright Act* but will be distinguished from traditional works (p. 9).

In general, the government has viewed the report favourably and recent legislation incorporates some of the recommendations.

In May 1987, Communications Minister Flora MacDonald tabled new copyright legislation in the House of Commons in an attempt to remedy several of the long-needed improvements to the 1924 Copyright Act. The bill provides increased protection to software engineers, in that infringement of copyright (piracy) will result in harsher penalties. Fines for unauthorized reproductions have been increased from \$200 to \$25,000 with a maximum of \$1 million and prison terms ranging from six months to five years. Computer software is now recognized as belonging to its author and is protected for the life of the creator plus 50 years. Furthermore, the new act will provide an exception to the right of reproduction to permit the making of a back-up copy in case the original is destroyed accidentally.

The Copyright Appeal Board, set up in 1938, will be replaced by a new board that will be responsible for registering agreements between creators and the buyers of their creations, and also for making binding decisions, if arbitration is requested, when agreements between the groups cannot be reached.

The Department of Communications is planning to table more legislative changes in the Fall of 1987. Flora MacDonald has explained this multi-stage process: "what we have done is single out those things on which we think there is general agreement" (*Globe*

and Mail May 28, 1987). Later stages will deal with elements with which there is more controversy.

Conclusion

We should emphasize that a small nation with relatively few domestic inventions may not directly benefit from more stringent protection for intellectual property. In fact, some small nations may attempt to rely on foreign inventions without having to pay royalties. It may be the foreign creators of inventions who argue for the more stringent protection. Here we see the linkage between intellectual property issues and international negotiations over trade and investment. Many of the small, less developed countries (LDCs) may refuse to institute new protection for intellectual property. While there is no definitive proof as to whether a small nation will benefit from more stringent protection of intellectual property, it is clear that the MNEs operating within Canada generally support these policies as an essential foundation for their international specialization.

PART C

**EDUCATION AND RESEARCH: A NEW
HIGH-TECH STRATEGY**

Chapter XIII

The Rationale for Education and Research Policy

Introduction

This chapter considers issues that give rise to government involvement in education and research. In the context of high-tech and international competitiveness, these issues acquire a new urgency. The ability of a society as a whole to attract desirable types of high-tech investment and well-paying jobs will depend increasingly on the qualifications of that society's labour force. Rapid and significant changes in products and production technology mean that employee skills and education quickly become outmoded. Retraining will become increasingly necessary if employees are to be able to shift into new occupations or to new products and processes. Otherwise, rising unemployment will place an ever greater burden on society as a whole. Yet, for the individual, the necessary education and retraining may cost more than one can afford. Furthermore, greater job mobility means that the corporation will not invest in its employees' education as much as would be socially optimal because of the risk of losing the employee and the educational investment.

Chapter XIII discusses the ways in which modern technology dictates the meshing of education and research policies. In this context, it discusses the role of the general education as opposed to specialized education. It also emphasizes a new role for the corporation based on the need to relate education with job requirements, to retrain employees continually, and to link university research with commercial applicability. We explore this university-

corporate nexus through a presentation of U.S. experiences with new university-corporate relationships in the context of new research parks. The socially optimal output level in any economic activity is the one where the costs to society in producing that quantity are balanced against the benefits to society from its consumption. The activities of buyers and sellers in a free marketplace may lead to production of the socially optimal quantity, but there are a number of reasons why, with education and research, the marketplace fails to supply the socially optimal output.

Externalities

One familiar source of market failure arises when there are externalities. "Externalities are said to exist when there are interactions among economic agents (producers and/or consumers) that are not adequately reflected in prices" (Palda 1984, p. 17). Economic theory shows that the market will provide too much output when there are external costs generated by economic activity. Conversely, the market provides too little output when external benefits are generated. The socially optimal output level can be achieved in the presence of externalities only through intervention by government.

It is generally accepted that education generates externalities by conferring benefits on society as a whole, although there is little empirical evidence because the externalities are difficult to measure. Since the individual or corporation cannot capture these benefits, private investment in education will not be as extensive as would be socially optimal. The ability of an employee to leave the corporation and find an alternative job elsewhere adds to this problem. The corporation will not invest in its employees' education as much as would be socially optimal because of this risk of losing the employee and the educational investment. Private decision makers cannot capture all the returns to education. Consequently, government funding is necessary to achieve a socially optimal level. Firms that carry out research to improve processes or products cannot capture all the benefits of that research because other firms are often able to introduce new versions of the innovation without paying royalties to the originator. These external benefits may be conferred on firms that produce similar products or use similar processes. They may also be captured by downstream firms if the innovator produces an intermediate good whose price falls because its production cost has been lowered. The amount of R&D carried out by private firms will therefore be less than the socially optimal amount.

Although the empirical evidence about the externalities from research and development (R&D) effort is not widespread, it clearly

indicates that external benefits do occur. Scherer (1982) investigated the annual rate of return in the United States from R&D expenditure occurring to downstream users of intermediate goods and found it to be about 100 per cent. Mansfield *et al.* (1982) surveyed 17 "undramatic, run-of-the-mill" process and product innovations. They estimated the median private rate of return to the innovators to be 25 per cent, while the median social rate of return was 56 per cent. For 30 per cent of the innovations studied, the private rate of return was too low to justify the investment effort even though the social rate of return was high.

The Science Council of Canada (1984) states:

Most Canadian R&D expenditure appears to be process-oriented. . . . The benefits of this type of innovation are more likely to be concentrated within the firm that does the R&D (p. 32)..

Even so, Postner and Wesa (1983) studied 13 Canadian manufacturing industries for the period 1966-1976 and found that R&D had little effect on the productivity of the industries that carried it out but it did influence the productivity of industries they supplied.

With both education and research, the inability of the corporation or individual to capture these external benefits means that government funding is necessary in order that the socially optimal levels will be provided.

Increasing the Society's Rate of Economic Growth

Most significantly, education and research policies are a means of raising the growth rate of the economy as a whole. These relationships, and economists' analyses of them, were surveyed in an article by Griliches in 1979. Five years later, Griliches again examined the most important themes of research in this field including the "belief that invention and technical change are the major driving forces of economic growth" (Griliches 1984, p. 1). Recently, many countries have experienced what Denny and Fuss (1982) have referred to as "the great productivity slowdown," and this perhaps has intensified the argument for government funding of education and research as a means of stimulating economic growth. A closely related broad externality that impinges on society as a whole is that government revenues and expenditures are affected by the rate of economic expansion. In a time of large deficits, the argument for special education and research policies to provide jobs and growth, and to reduce social security payments for the unemployed, may receive strong support for this particular fiscal reason.

Public Funding as a Mechanism for Sharing Risks

Nearly everyone in a changing society must make judgements in the face of uninsurable risks. Personal decisions concerning education, career, and private investments all involve such risks. Since modern life has automatically subjected everyone to important risk-bearing, an argument is sometimes made for a new kind of government intervention that pools specific risks and rewards, so that individuals are less exposed to economic misfortune. That is, government may be able to insure against risks in a situation where citizens want such insurance and where no institution other than government can provide it. The enormity of the risk-sharing may be so great and its nature so complex that private institutions may not be able to administer it effectively. Present-day economic activities now involve such new and severe risks for all citizens that the optimal social contract may entail a sharing of many of these risks, as well as a sharing of the concomitant rewards and losses. Arguments for such risk-sharing may recommend the provision of public funds for many specific purposes: the personal acquisition of knowledge and skills; employment relocation and retraining; or corporate investments in research and development.

Of particular importance is the view which sees the development of human capital as the result of individual entrepreneurial decisions and which sees risk-sharing as an appropriate insurance purpose of government policies. This view has received special attention from several authors. Harris *et al.* (1984) have suggested that a

well-known failure in the market for human capital stems from the inability of workers to diversify their portfolios across alternative skills or professions. As a result, workers are said to be too risk averse from society's perspective. Numerous schemes have been proposed to offset this risk aversion, including the financing of job retraining and other subsidies to promote human capital formation (Harris *et al.* 1984, p. 112).

Some observers have applied a similar argument to the Canadian government programs that provide public funds for private corporate R&D (Palda 1984). The Economic Council of Canada (1982, 1983) has analyzed these activities in several of its publications. One rationale for a public sharing of uninsurable risk of capital loss is illustrated by the following example taken from one of these publications:

Suppose that there were 100 R&D projects that could be undertaken in totally unrelated fields, each costing \$1 million and each with a 50 per cent chance of success.

Suppose further that for each successful project, the revenue would be \$4 million, thus generating a profit of \$3 million; for each unsuccessful project, the \$1 million would be lost. If all the projects were undertaken, one would expect about 50 of them to succeed, generating a total profit of \$150 million (50 x \$3 million). When the \$50 million spent on the 50 projects that are expected to fail is subtracted from that amount, there is a net profit of \$100 million for all the projects combined. Yet it is quite conceivable that a firm would hesitate to invest \$1 million if the 50 per cent chance of a \$3 million profit were offset by an equivalent chance of losing its investment. If such risk aversion were widespread, most of the 100 projects could remain untackled, and most of the \$100 million gain could remain unrealized (Economic Council of Canada 1983, p. 32).

This example illustrates that risk-spreading can be a reason for government to assist the R&D process, but that it need not be a reason if firms are prepared to face risks or if the odds of success are not good enough, even from society's point of view.

The application of the government risk-sharing argument to corporations seems to involve the concept of an acceptable size of downside risk based on the size of the decision-making entity. In the above example, a large enough corporation would conduct all the projects, but a corporation of adequate size may simply not exist. This type of market failure, based on the inability of the private market to create a sufficiently large corporation to conduct the necessary number of high-risk R&D projects, may vary in significance over time and among countries. For example, it may be that the United States has venture capital investment firms of greater number and size than does Canada. So this government risk-sharing argument for public funding of private corporate R&D may be appropriate in Canada but not in its larger neighbour (Conklin 1986, p. 57).

Competitive Imperfections

Competitive imperfections can also lead to sub-optimal output levels. While the implications of monopoly on the quantity of output are well known, the implications of market structure for the level of R&D effort are less clear. For example, it could be argued that firms in fiercely competitive industries do not accumulate the retained earnings needed to fund research because their profit margins are small. Moreover, the benefits from innovation would be short-lived if competitors could easily mimic new processes or products. On the

other hand, the potential to capture a large market share from competitors could provide an important stimulus to R&D effort. Indeed, Schumpeter (1942) argued that the profits from monopoly power provide the incentive to innovate. They also provide the funds necessary for research. He believed, however, that the monopoly power of any individual firm would be short-lived as newly competing firms responded with their own better innovations. He called this social process "creative destruction"; new innovations arise to replace the old and are themselves creatively destroyed by yet more innovations.

The empirical evidence about the relationship between market structure and R&D effort is inconclusive, thus the appropriate role of the government is not clear. Nelson and Winter (1978) used simulation techniques to show that an industry comprising small firms of equal size can be quickly changed to one that is highly concentrated through technological competition. This phenomenon is especially potent in industries like computers, where "success breeds success." Karnien and Schwartz's (1982) survey of the U.S. literature indicates that R&D effort varies directly with the size of a firm up to a point, after which the relationship becomes unclear. The Economic Council of Canada's Interim Report on Competition Policy (1969) found no relationship between firm size and R&D intensity, measured as a percentage of sales. Green (1985) makes the interesting point that:

A number of quantitative studies of the determinants of the level of industry or firm R&D expenditures in Canada have found government grants or subsidies to be an important, often the only statistically significant explanatory variable.

Distribution

Davies has argued that maintenance of social mobility and equality of opportunity provide an important reason for government intervention into education. Furthermore, scientific progress can have differential impacts across regions that justify government intervention, as Conklin (1986) has discussed:

To the extent that innovation is an inter-firm process with one company's entrepreneurial activity being linked with that of others, it may be essential for some firms to locate near one another. To the extent that innovation depends upon university research facilities, firms will locate near the leading universities and, consequently, near each other. To the extent that innovation requires highly sophisticated

and specialized scientific skill, it may be necessary for an entrepreneurial firm to locate near similar firms, from which it may entice employees. . . . The significance of these tendencies can be seen in the postwar growth of microelectronic firms, which have concentrated in a few urban regions—highway 128 in Boston, the Silicon Valley near Stanford, and, in Canada, the Ottawa Valley and Metropolitan Toronto. To the extent that the ready availability of natural resources loses its importance as the determinant of investment location, and to the extent that urban and regional concentration is intensified by the special agglomeration economies of entrepreneurial activities, we may expect an increase in disparities based on city, region and province in Canada. In the process of entrepreneurial adjustment, we may expect some cities to forge ahead quickly while other cities and regions will suffer as their growth prospects diminish. It is therefore likely that social and political conflict over the optimal pace of adjustment and over the appropriate role of government will increasingly follow regional and provincial lines. (Conklin 1986, pp. 51-52)

In examining the location decisions of high-tech firms, Miller (1986) has found that Toronto, Montreal and Ottawa are Canada's leading centres of high technology having 405, 365 and 220 high-tech firms located respectively in each. Faced with these tendencies for high-tech firms to concentrate in a few urban centres, governments may see a need to provide financial incentives to assist other regions. Without such government intervention, the other regions may not be able to benefit from the high-tech era.

Engineering a High-Tech Advantage

Wonnacott (1985) has pointed out that natural resources are not typically an important factor in the development of high-tech industries. Moreover, the capital requirements are generally available because of the increasing international mobility of capital. Technology and a highly-trained and skilled work force have become the critical consideration. Government can engineer a comparative advantage in high technology products by providing an infrastructure conducive to its development and application through appropriate research and education policy. Wonnacott suggests that the advantages conferred on the first country to develop a product may overcome other disadvantages and permit the first-in country to enjoy the benefits of market power. The early decision to pursue the

development of high technology industries by the Ministry of International Trade and Investment (MITI) in Japan is often cited as an example of a successful effort to engineer a comparative advantage.

The following points from Wonnacott (1985) clarify the rationale for engineering a comparative advantage:

- Differences in factor endowments—especially between North America, Europe, and Japan—are no longer as important as they used to be because some factors have become more freely available. For example, one factor crucial for high-tech industries—namely, capital—has become increasingly mobile between countries. And the more freely capital moves between countries, the less important are differences in labour/capital endowments. Moreover, in many new high-tech products, natural resources are not an important factor.
- Technology has become a more critical consideration. Indeed, it can be argued that, as an extension of the idea of human capital, technological capacity should be viewed in its own right as a factor of production—and an increasingly important one at that. Since technological capacity is, like capital, "created rather than endowed," a natural question is: How can it be created, and thus provide a future comparative advantage in technology-intensive industries—which in many (but not all) cases are rapid growth, high income industries?
- Economies of scale may mean that the first country to develop a product will be the low-cost producer—even though it may not have the lowest attainable cost curve (i.e. even though, roughly speaking, it may not have a comparative advantage). Its "comparative disadvantage" may be more than offset by the advantage it achieves from the head start which gives it the highest volume and lowest cost. It may then be able to use this "volume" cost advantage to deter entry by other producers—perhaps even producers with a slightly lower cost curve, but inadequate volume to compete (Wonnacott 1985, pp. 77-78).

Brander and Spencer (1983) show that this last point is significant for political entities considering the use of subsidies to optimize their interests *vis-à-vis* other political entities. Whether a comparative advantage can be engineered or not, education and research will require attention if Canada is to attract investment in high technology industries. For example, Canada's position as a nation endowed with highly trained professionals and technicians cannot be taken for granted. Many studies have concluded that Ontario

universities are underfunded and that research facilities are in consequent decline. The problem is probably not confined to Ontario. At the management level, Daly (1980) found that the proportion of managers in Canada with university training has historically been below that in the U.S., reflecting the smaller percentage of young people who attend university in Canada and the lower proportion in commerce.

The Proper Quantity of Intervention

The above discussion indicated that public intervention in the private sector can be a reasonable response to a number of factors. Government intervention is not an automatic panacea, however.

First, public intervention is not a costless procedure. The government incurs labour and capital costs, and the optimal quantity of intervention is the one that balances these costs against the benefits that intervention generates. The problem is further complicated by the fact that the costs and benefits are often difficult to measure. Moreover, the competitive mechanisms that force firms in the private sector to be technically efficient generally do not face the government.

A second factor that gives rise to the need for cautious public intervention involves the potential divergence between the official objective of a government program and the internal goals of the bureaucracy implementing it. For example, Davis *et al.* (1980) studied an R&D subsidy policy pursued in the United Kingdom, where the policy objective was to pick winners, but where it was discovered that the real beneficiaries were relatively unprofitable and high unemployment industries.

A third reason for caution arises because government policy itself can generate unwanted market distortions. The National Energy Program is an example. Monopoly protection provided by regulatory agencies such as the CRTC is another.

The Meshing of Education and Research Policy

Most of the market failures and third-party effects that prevent individual decision making from leading to socially optimal investment patterns are true for both education and research. Much more than this common rationale for public policy links research and education. In fact, they have become so enmeshed that they are best discussed together. Policy directions and funding allocations in each of these areas have serious implications for the other.

One of the principal reasons for integrating research and education policy is that both are intimately related to commercial activities. Education and research is usually undertaken with the expectation that it can someday be applied in the real world. Nearly all scientific endeavours and education programs ultimately have some impact on business processes, products or personnel. This research-education-business nexus is becoming increasingly important in determining a society's policy in this domain. The business perspective that focuses on the commercial applicability of education and research forms a common purpose for each. The impact of research and education in creating more and better employment opportunities forms a common social concern.

The effectiveness of research policy depends on the availability of personnel who have been educated appropriately. Public decisions about the size and nature of the educational system, the development of advanced skills, and the pursuit of particular research themes, inevitably affect the scientific success of governments and corporations. The application of new ideas in government and corporate activities can be facilitated through linkages with post-secondary educational institutions. Creative synergism can be fostered through such linkages, and both research and education can benefit.

Favourable public support for education and research will depend on the degree to which the average citizen can be convinced that investment of his or her tax dollars will yield substantial social returns. Favourable public support will depend on the average citizen's seeing that his or her own future well-being can be enhanced. From the perspective of the average citizen, such policy can best be understood as a coherent and unified government thrust to advance our economic productivity in the new technological era and to improve the abilities of individuals to obtain rewarding jobs as the economic environment changes.

The Need for a General Education

Both the Natural Sciences and Engineering Research Council and the Ministry of State for Science and Technology focus on the education of scientists and engineers. However, even the purely scientific research process may involve experts from the humanities and social science disciplines. In particular, the commercial application of research depends on the availability of personnel whose principal training is in non-scientific fields. The development of new products requires professionals who have studied various aspects of human behaviour and human needs. Successful labour relations and personnel management are also essential if R&D is to result in rapid and

substantial changes in the nature and content of jobs. International competitiveness requires experts who have studied other societies. Mathematics, computer software, and statistical analysis have become an intimate part of most R&D processes as well as business practices.

Professor Andrew Grindlay has discussed the role that graduates of today's business schools can play in designing and building corporate information systems. Scientific data must be analyzed and presented appropriately if it is to contribute most effectively to real-world decision making.

A growing number of Canadian companies are looking to the Business Schools for graduates who can bridge the communications gap between the user-managers and the more technical systems people (Grindlay 1986, p. 9).

Jerry Dermer has also emphasized the need for skilled management personnel if new technology is to be implemented. In fact, Dermer claims that Canada needs entrepreneurship and marketing skills even more than we need R&D expenditures:

Entrepreneurship and marketing are the major weaknesses, not R&D support. Perhaps our greatest failing in attempting to manage the growth of Canada's technology-producing sector is in over-estimating the importance of technology and under-estimating the importance of entrepreneurship and marketing (Dermer 1984, p. 41).

The Corporate-Higher Education Forum (CHEF) was founded in 1983 by 27 university presidents and 35 corporate chief executive officers. Its purpose is to examine university-corporate relationships and to develop appropriate policy recommendations. In 1984, CHEF commissioned a study on the adequacy of university education relative to the current human resources requirements of Canadian corporations. Of striking significance was the finding that, for many students, education has become too specialized: that liberal arts programs have an important role to play in our high-tech world. To quote the authors of this report:

There seems to be a recognition that the trend toward specialization has had adverse effects for corporate employment. In a 1984 speech to Concordia University, Dr. Patrick Kenniff stated that those in the university system had failed to grasp what sort of graduates were needed in the high-technology automated world. 'In assuming that

our contemporary mandate was to train people to accomplish specific tasks, we forgot that capable generalists skilled at melding technological issues and requirements were the real needs.' Based on a survey of data processing managers in U.S. companies, Friedman and Greenbaum (1984) found that a 'bachelor's degree (in computer science) is still the main ticket into programing and systems work, but a large number of managers expressed frustration with computer science graduates they hired and look with interest to liberal arts or business students.' Mr. E.E. Walker, Vice- President, Gulf Canada Limited, noted in a recent speech (1985) that 'when we in business go recruiting, we tend to be looking for a specialist. But no sooner is the individual inside the door then we are wanting him or her to start displaying generalist tendencies.' Bolt *et al.* (1985) called for an increase in general management and interpersonal skills, in addition to an understanding of new technologies in business programs. Liberal arts graduates were found to do well in the U.S. Bell system (Beck 1981). The U.S. Business-Higher Education Forum (1985) also advocated more broadly based education in business programs. In a recent monograph, Bok (1982) examined the role of universities in contemporary society. He suggested a practical approach emphasizing the importance of leadership and other general skills.

In summary, we have found a consensus in the literature that general education skills are essential to university graduates employed by corporations. The generalist issue carries over to specialized programs as well. Clearly, a technologically advanced nation such as Canada needs specialists in engineering, computer science, etc.; however, these graduates also need general skills to function in corporations (Rush and Evers 1985, p. 44).

The Canadian Manufacturers Association (CMA) issued a 1984 report on education policy in which it also has expressed this business need for general education. This CMA report goes beyond the daily corporate tasks to address the long-term issues of social objectives and social values:

The importance of an excellent education system to the business world goes well beyond its roles in education and training future workers and advancing science and technology Learning deals with questions of alternatives and values, both of which affect the ways in

which technology is controlled and research is directed. Learning also embraces the liberal arts, the humanities and the social sciences, all of which provide business and society with a breadth of vision about the relationship between technological progress and the quality of life. Our workers and managers must share a rich base of knowledge in which the liberal arts, the humanities and the social sciences play an important role.

The vitality of industrial enterprise, therefore, is related closely to the ability of our schools and universities to carry out their purpose. The capacity of the institutions of higher education to contribute in terms of education, training, research and public service is a matter of critical importance to the long-run progress and prosperity of business and Canadian society (CMA Task Force 1984, p. 5).

This appreciation for the generalist education also holds true when we turn to the impact of new technology on job content and to the consequent need for retraining. New technology eliminates some job functions while creating new tasks. Can we forecast future business needs for specific skills and can our education institutions develop programs for these specific skills? This subject is a central concern of a 1986 volume, *Adapting to Change: Labour Market Adjustment in Canada*. Written as a background study for the Royal Commission on the Economic Union and Development Prospects for Canada, this volume concludes that changes in job content cannot be forecast accurately. Our formal education system cannot prepare students for the precise job content needed in the future. Nearly all of us will find that our job content will require new skills and we will each need continual retraining. A general education can provide a student with the ability to learn. As new skills become necessary, a general education may be a better basis for retraining than a technical, specialized education would be.

The 'generalists' stress learning the ability to learn, to think and to communicate rather than specific skills. Although there is not a consensus on the recommended curriculum, most would include basic reading, writing, communications and computational skills. Implicit or explicit in the generalists' position is the view that the skill content of many jobs may change unexpectedly and the ability of individuals to adapt to these changes will be enhanced by a foundation in these basic skills. Associated with the labour market planning approach is the

'technicians' position that emphasizes training for specific occupations and skills, and would typically advocate giving higher priority to science and computing programs in schools and to vocational over general schooling. Implicit or explicit in this approach is the view that future skill requirements can be forecast with some reliability and that formal retraining programs can be instituted in response to changing labour force needs (Riddell 1986, p. 25).

After examining a wide variety of evidence, the authors conclude that there is "greater support for the generalists' than the technicians' position" (Riddell 1986). According to Steven Globerman (1986), it can be argued that "embodied" formal education facilitates workers' on-the-job efforts to adjust to technological change. The key role of education is not to teach specific skills but rather to prepare students for this continual retraining process. "One ubiquitous finding is that most cognitive job skills, general or specific, are acquired either formally or informally on the job after a worker wins an entry job" (Globerman 1986, p. 55).

The Role of Corporations in the Educational Process

These findings lead to very important implications for the role of corporations in education policy. The rapid and continual changes in job content that are inherent in our new technological era mean that society must rely on corporations to retrain and upgrade our labour force. Formal educational institutions are simply not able to fulfil this responsibility. Within corporations, this emphasizes the need for attention to retraining programs as a major responsibility of management. Improving the effectiveness of retraining processes may be a central determinant of future corporate profitability.

For society, the traditional practice of channelling public funds into formal education institutions must be supplemented with assistance for corporate educational programs. In recent years, a variety of funding practices have been directed toward this objective. It is now important that these be evaluated on a continuing basis. Since public funding of on-the-job training is relatively new for Canada, it is likely that improvements can be developed over time. Particular practices and their modification should be regarded as experimental and their continual review should be seen as essential.

From a business perspective, a 1983 IBM report has emphasized the enormity of the requisite retraining necessary as part of technological progress:

The education and training of young people entering the work force, and the re-training and placement of displaced workers will be the major challenges of the next decade.

Estimates indicate that more than 20 per cent, and possibly 40-50 per cent, of the work force will be displaced by the early 1990s and need training for new jobs. The people leaving schools today are not educated and trained for the job requirements of the 1980s and 1990s.

The lack of training will impact on unemployment in two ways. First the shortage of trained people will slow the introduction of new technology, and this will impair the efficiency and competitiveness of companies. This will result in slower recovery and growth. Secondly, the displaced worker will remain unemployed until he can be re-trained (IBM 1983, p. 14).

Davies and MacDonald have examined the use of public funds for on-the-job training in their 1984 book, *Information in the Labour Market: Job-Worker Matching and Its Implications for Education in Ontario*. This book emphasizes the needs of young people. We can be quite sure that, initially, all young people will require substantial on-the-job training, and this will make corporations reluctant to hire them. Public subsidies to corporations are justified in the interests of achieving this practical education. Administrative costs and bureaucratic red tape could be minimized by simply giving all corporations a uniform wage subsidy geared to the employee's age. Davies repeated this recommendation in his 1986 Royal Commission study:

One universal and administratively cheap proposal would be to offer wage subsidies inversely related to age for all young workers—for example, \$1.50 per hour for those aged 16 to 18 and \$1.00 per hour for those 19 to 20. It will be argued by some that this would just lead to an expansion in dead-end jobs for the young, because of the lack of a required training component in the jobs subsidized. Some of the subsidy would no doubt go to support such jobs, but this has to be weighed against the benefits of the scheme, including reduced youth unemployment as well as greater OJT [on-the-job-training] and the considerable cost of enforcing standards. If the minimum wage is severely reducing OJT for workers in the target age brackets, then the subsidy creates critical room for the intensity of training to increase (Davies 1986, p. 195).

This section has examined the meshing of research and education policy in elevating the qualifications of personnel and in assisting personnel to develop new job skills. We have seen arguments that the advancement of technology depends upon this process.

It is commonplace to refer to this process as "education." However, to refer to it as education can miss important aspects that we have noted in this section. Particularly in the graduate's first job and in the later retraining experiences, today's corporations are the key players. Underlying this is the necessity for "learning by doing," that is, education in the workplace. Much of what today's personnel need to know can only be learned on the job. In this sense, we can no longer leave education to the educators. Rather, corporations must be seen as educational institutions, with important implications for public funding and corporate practices. Canada's ability to create and implement scientific advances will depend upon whether we shape our public policies from this perspective.

R & D: The University-Corporate Nexus

In the preceding section, we have seen that our high-tech society has brought education and research policy together in the development of qualified personnel. When we turn to the creation and implementation of new knowledge, we again see the meshing of these two policy areas. And again we see business applicability as a powerful force drawing them together.

Much of today's economic progress has originated in the research of universities. Microelectronics and computers, biotechnology and genetic engineering, fibre optics, lasers and telecommunications are all being built upon the discoveries of university professors as well as upon research done within corporations. Modern advances in medicine and health care have also depended on university research. Agricultural productivity has increased as a result of new seeds, chemical fertilizers and new concepts of livestock breeding that have originated in university research.

Canada's 1984 Task Force on Federal Policies and Programs for Technology Development emphasized the importance of these university-business research linkages:

If university laboratories were ever "ivory towers," they are emphatically less so today. Universities now play a central and strategic role in Canada's overall research effort. They tend to take the longer view; although most university research is fundamental, and is concerned with the earlier stages of the innovation chain, it is a crucial link in that

chain. Fundamental research carries an additional benefit: it fosters the education process itself. The social benefits of education – which produces ideas as well as highly-skilled people – plus the long-term benefits of scientific research, make university research extremely cost-effective.

Industry is increasingly recognizing the need to involve the universities in the longer-term aspects of technological development, particularly through research and engineering which is the main conduit between the two sectors. But this dialogue is only just beginning. In the U.S., engineering institutions such as MIT, Stanford and Carnegie-Mellon have become key elements in the maintenance of America's industrial competitiveness. Both industry and government in the U.S. seem more keenly aware of the potential for close cooperation with universities. American universities, in turn, are better equipped to respond to these new industrial demands, in part due to extensive equipment donations by industry. These are due to the more generous tax treatment for such donations in the U.S. We believe it would assist universities if similar provisions were available in Canada (Canada, MOSST 1984, p. 19).

It is important to emphasize that not only the research of physical and biological sciences and engineering underlies our economic progress. University research in the social sciences and humanities is also contributing to our society's economic activities. Improvements in business practices have benefited from the research of professors in the many fields that explore the various aspects of human behaviour. Knowledge of people and their diverse needs underlies successful marketing and hence our competitiveness. It also underlies successful labour relations and personnel management. Implementation of new technology depends on the skills and knowledge of our business executives. Understanding foreign legal systems and modifying our own laws can influence our international competitiveness. In these times of rapid change, analyzing the many social forces impinging on our lives is essential to our ability to cope as a society and as individuals. Rapid shifts in our population's age structure, for example, have an impact on nearly all government social programs. They also affect the consumer demand for the various types of privately produced goods and services. Mathematics, computer software, and statistical analysis have become an intimate part of most of these research areas.

The Distinction Between Basic and Applied Research

"Basic research" is the pursuit of knowledge when the ultimate applicability of that knowledge is not clear, and when some time may elapse between the initiation of such research and its commercial use. Individual corporations cannot afford on their own to undertake much basic research because the ultimate results are uncertain, and because any one firm cannot capture all the benefits, even with patent protection. Yet, since the economy as a whole will gain from basic research, it is important for our universities to play a major role, using public funds.

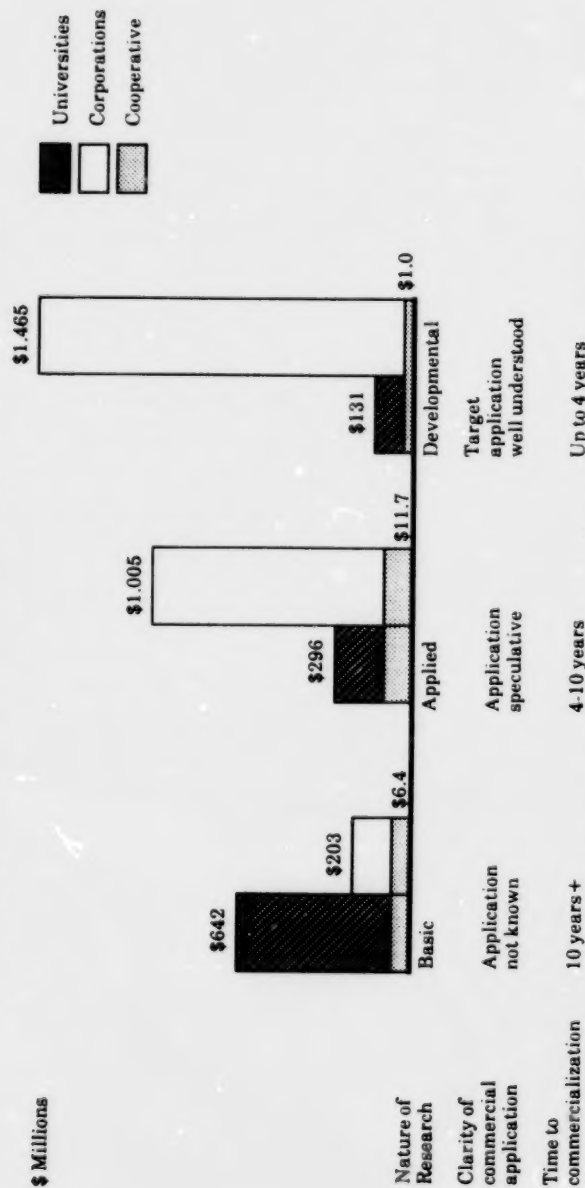
At some point in a basic research program, a corporation will perceive a particular commercial usefulness and will direct its own "applied research" towards that specific purpose. In this way, applied research by private corporations can develop out of the basic research of universities.

The division between basic and applied research is not clear-cut. Attempting to define "basic" as opposed to "applied" research – and to restrict public funding in accordance with such a definition – will not be easy. Funding processes must consider research proposals on their own merits, and must possess the wisdom to make judgments concerning the propriety of using public funds to finance these proposals. One concept that may provide guidance is found in the phrase "pre-competitive research," which describes industry-university collaboration where a number of firms may find it useful to share in the activities. A time will probably be reached in any particular research process when the collaborating firms wish to cease their collaboration in order to pursue various questions of applied research individually in a competitive manner.

Spending Smarter, a 1985 publication of CHEF, contains an analysis of Canadian R&D expenditure data from this perspective. The data are divided, in Figure 13.1, into "Basic" where the application is unknown and will probably occur only after at least 10 years; "Applied" where the application is speculative and will probably occur four to 10 years in the future; and "Developmental" where the application possibilities are clearly seen and will occur within four years. Not surprisingly, the role of Canadian universities is greatest in basic research and least in developmental research.

Figure 13.1 reveals the importance for policy purposes of dividing R&D into at least two separate components, and perhaps even three.

Figure 13.1
Research Profiles of Universities and Corporations 1984 Estimates



Note: Corporate profile is based on McKinsey analysis of Forum Corporate R&D Expenditure Survey of 49 leading performers responsible for more than 56 per cent of 1984 corporate research spending as estimated by Statistics Canada. University profile is based on National Science Foundation estimates of United States college and university research profile applied to 1984 Canadian higher education research spending estimated by Statistics Canada.

Source: CHEF, *Spending Smarter*, p. 26.

Focusing on Canadian Commercial Applicability

For several reasons research in Canadian universities should include those subject areas that are most likely to lead to commercial applications.

First, Canadian corporations doing applied research will find it helpful if they can look to Canadian universities for the basic principles upon which their innovations can be based. It is true that Canadian corporations could look to universities in foreign lands. But the technical transfer of knowledge will be more likely if it occurs between Canadian universities and Canadian corporations. Furthermore, in those subject areas where Canadian universities can be world leaders in basic research, Canadian corporations can have a strong competitive advantage.

Second, there can be a creative synergism between the university professors who are concentrating on basic research and the corporations that are attempting to apply that research. Both can acquire useful insights as a result of interrelationships. In the advancement of knowledge, there is more than a technical transfer of information. The process of communication can be creative. Ensuring that Canadian universities are involved in subjects of relevance to Canadian corporations can benefit the people involved at both of these levels.

Third, a corporation wishing to conduct its own applied research must be able to hire personnel who have been trained in research skills. It is largely to our Canadian universities that our corporations must look for the new employees who can develop and implement production processes and management and marketing techniques.

Research within universities is intimately linked with the universities' teaching responsibilities. Research is important in determining the quality of instruction. Students can acquire the ability to conduct research in their future professions only by participating in research projects while they are in university. Furthermore, the most talented professors will leave Canada and migrate to those countries or jurisdictions which provide them with more funds to pursue their research. The universities' abilities to convey the most recent advances in knowledge—particularly at the level of graduate studies—depend on their research facilities and their professors' talents. And these depend on the level and effectiveness of university research funding. Thus the career opportunities of students and the staffing possibilities of corporations are inextricably linked with university research. In medical fields, research in universities is closely tied to clinical practice. The analysis of treatments and patient outcomes underlies much basic research at the same time as it forms a part of the health care process.

In considering these relationships between Canadian business activities and university research, it is important to emphasize the role of graduate studies. Students in graduate programs are the ones most involved in research. And it is from these graduate programs that Canadian businesses can hire their own industrial researchers. Professors teaching graduate courses have a special need to stay at the forefront of their field of knowledge so they can teach effectively. Therefore, graduate school professors are usually involved in research to a greater degree than others. It is from graduate schools that universities will draw their future professors, and concerns have been expressed about possible shortages of potential professors, particularly in view of projected age and retirement profiles. Not surprisingly, graduate programs cost more per student than do undergraduate courses. Yet the thrust of our argument is that this extra expense per student is worthwhile from society's perspective.

Many specialists in this subject express skepticism about direct and automatic links between university research and the adoption of new technology based on that research. It has been argued, for example, that the United Kingdom has been a world leader in university research, but has failed to utilize the results of that research as effectively as other nations have. This emphasizes the need for collaboration between Canadian businesses and universities, and it emphasizes the manpower training component and human element in the research process.

An appropriate conclusion for this section is the opinion of CHEF after having examined Canadian experiences:

The picture of Canadian research and development investment patterns that emerged in this project has convinced us that improved cooperation between universities and corporations represents a genuine and substantial opportunity for Canada to deploy its research and development (R&D) resources more effectively and that this opportunity should be exploited aggressively (CHEF 1985, p. 3).

U.S. Research Parks

High-tech firms require sophisticated personnel and equipment to perform their research and development, both of which are expensive and hard to locate. The obvious solution is some sort of sharing relationship among those involved in high-tech R&D. And with two thirds of the nation's basic science research being done at universities, it seems natural that universities and high-tech firms should work together (Beyers 1983, p. 11).

With the exception of MIT and Stanford, however, American universities and colleges have traditionally discouraged a link-up between business and higher education facilities. Faculty who researched ideas for commercialization were often viewed with distaste (Wall Street Journal September 17, 1985). But faced with the decline in federal research funding (down 33 per cent in real dollar value from 1968-1983, half of which occurred from 1981-1983) these institutions have begun to change their attitude towards such a partnership and are starting to embrace business as a positive funding source (Beyers 1983, p. 12).

Research parks are usually defined as clusters of research-intensive firms and facilities on a site near a university. These parks not only attract high-tech firms, but also provide seed beds for spin-off companies (United States, OTA 1984, p. 59).

A 1983 General Accounting Office (GAO) report stated that 27 university-related research parks had been started since 1951. Furthermore, six had clearly succeeded, 16 had failed, while the remaining five were at an intermediary stage (United States, GAO 1983, p. 10). Although there is no guarantee that a research park will succeed, there do seem to be some ground rules with regard to success:

- the city or county must be a nice place to live
- the park must be near a good and large university
- the university must have research facilities
- the area must have a skilled labour force
- the park must have excellent management staff (*The Economist* March 16, 1985, p. 89).

The park is designed to benefit the high-tech firm and the university. The most obvious benefit to both parties is that the park breaks down the "spatial barriers between university and industry researchers," allowing them to interact with greater ease and frequency. The proximity of the park encourages both university faculty and industry personnel to take advantage of each other's resources. This is especially important to firms that cannot afford the expensive equipment needed for their own research. In addition, industrial researchers often attend lectures or serve as visiting professors at nearby universities, while faculty are given a better opportunity to act in a consultative capacity to these firms (United States, GAO 1983, p. 10).

This interaction also enhances the opportunity for new cooperative programs through which lab facilities are shared, and increased interaction between the university and the industry improves the

education level of students as well as their future employment opportunities (United States, GAO 1983, p. 10). A further benefit for high-tech companies planning to move into a research park is the Federal Research and Development Limited Partnership program, which allows companies to take a more rapid deduction of research costs if the work is done with a university (*New York Times* November 12, 1985, p. C1).

The parks are usually designed to provide a campus-like setting, offering low density development among the natural habitat of the area. Generally the area is already preplanned by the university with roads and amenities such as sewers, electricity and water lines ready to be used. Each park, however, has its own set of services, facilities and financial arrangements available to individual firms (Thomas 1983, p. 77). This is where the city, county or state in question can play a major role in the success of the park. These are the units that provide public services, prepare zoning regulations and offer subsidized financing for park tenants (Malecki 1984, p. 273). However, once a firm has moved into a park, the university usually demands strict compliance with various land development guidelines; such as building size, design, finishes, parking, signage, grading, lighting, noise and traffic (Thomas 1983, p. 77).

The federal government's role in the creation of research parks has been very small and indirect, mostly through funding university programs which later became technological research centres. But there have been instances, as with the University of Utah Research Park, where the land for a park was donated by the federal government. This park was also the recipient of a federally funded innovation centre granted through National Science Foundation funds. Federal laboratories have also been moved into parks such as North Carolina's Research Triangle to help to spur park growth (United States, GAO 1983, p. 19).

The first research park in the United States was started by Stanford University in 1951. The park has now grown to house about 90 firms employing 25,000 people (Beyers 1983, p. 12). Land in the park was originally developed on a 99-year lease, but recently all new leases have had a maximum length of 51 years (McAndrews, undated). The park was originally designed to help to alleviate the heavy tax burden the campus's vast acreage was posing for the university (Board of Trustees of Stanford University, March 12, 1974, p. 6). It was also hoped that the promotion of a university-industry research link-up would stem the drain of staff and students to other states or universities (United States, GAO 1983, p. 15). Thus, the park is designed to ensure that innovation and entrepreneurship remain vigorous at Stanford.

North Carolina's 5,500-acre Research Triangle park is the largest planned research facility in the United States (Thomas 1983, p. 76). Located in Greenville, N.C., the park offers firms close access to Duke University, the University of North Carolina and North Carolina State University. This state-sponsored effort was created because of the belief that increased research and education would lead to increased industrial growth (*Plants, Sites and Parks* November/December 1985, p. 137). The park opened in 1959 and has traditionally limited occupancy to firms "engaged in research, development and scientifically-oriented production" (*Plants, Sites and Parks* November/December, 1985, p. 137). By 1965, only nine laboratories with 1,000 employees had set up shop in the "Triangle," until IBM and two federal laboratories moved into the park later that year (*The Economist* March 1985, p. 19). In 1984, four firms invested an additional \$129 million in new and expansion projects, so that by 1985 the park employed over 20,000 people from over 40 firms (*Plants, Sites and Parks* November/December, 1985 p. 137).

Unlike Stanford, the Research Triangle Park's heavy state involvement allows it to grant tax incentives, land and building subsidies, grants, loans, and debt and equity capital to park occupants (Luger 1984, p. 282). One major concern of scholars has been the park's concentration upon the recruitment of out-of-state firms for the park; little has been done to develop "home-grown" high-tech companies (Luger 1984, p. 288).

Conclusion

Throughout the world, the creation and diffusion of new technology is now perceived as the foundation for future economic growth and prosperity. Less developed nations are quickly adopting technologies that were created in the advanced economies of Western Europe and North America. This technology transfer has altered traditional patterns of comparative advantage and international trade. Meanwhile, the advanced economies have become increasingly concerned about their ability to innovate. This race for more efficient technology has become a major determinant of international competitiveness. As participants in this race, individuals and corporations now look to their governments for public policies to help them to win. Among these policies, we believe that education and research policies play a central role.

The role of labour qualifications as a determinant of corporate location decisions is particularly important. The high-tech sector includes a wide variety of occupations, requiring different levels of education and skills and paying different levels of wages. A society that wants to attract the high-tech activities that offer high wages

must develop the corresponding levels of education and skills. Labour is not homogeneous. Capital can be invested in labour so as to increase its economic value. Moreover, a society that ignores this relationship will be destined for the lower end of the job scale in the new world economy.

The information technology sector is undergoing constant change. To retain the best jobs and highest wages, a society must continuously re-educate and retrain its members. High-tech corporations continually find that their sales mix is changing, with new products and services being combined to create new solutions. This trend has brought about a change of emphasis in production activities from economies of scale to economies of scope, whereby retaining a competitive lead requires the ability to respond to the constantly developing needs of the market. Indications are that this will result in greater labour requirements that emphasize skill level and adaptability. From this perspective, education and research can be seen as the central mechanisms for creative adjustment in an ever changing world. They will form the cornerstones of future Canadian competitiveness.

Modern technology dictates the meshing of education and research policies. In this context, Chapter XIII has discussed the role of the general education as opposed to the specialized education. It has also emphasized a new role for the corporation based on the need to relate education with job requirements, to retrain employees continually, and to link university research with commercial applicability.

Chapter XIV

Education and Research as Adjustment Policies: The Japanese Experience

Introduction

The success of Japan's technology-intensive industries can be attributed, at least in part, to Japan's emphasis on education and research policies. As a result of these policies, Japan has had a high rate of human capital formation that has facilitated adaptation to new international economic circumstances. According to some indicators, Japan maintains a higher level of basic literacy and mathematical skills than the United States and, furthermore, has continually produced more engineers than most other countries in the world. The workforce has been highly motivated and disciplined, and many commentators have praised Japanese management-labour relations. This chapter will outline education and research policies of Japan and show how they have helped to improve Japan's international economic standing. This chapter will also comment on the new challenges facing Japan as it shifts from process innovation, based on the modification of foreign technologies, to more original innovation, based on indigenous Japanese inventions.

This chapter was written by John W. Mitsopoulos, a research assistant with the Institute for Research on Public Policy.

A New Emphasis on Research Policies

Japan's research and development (R&D) expenditures, as a percentage of gross national product (GNP), are among the highest in the world. In 1985, Japan spent a little over 2.5 per cent of its GNP on research and development, or about \$23 billion. The government hopes that by 1990 it can increase these expenditures to 4 per cent of GNP. What is significant in Japan is that direct government R&D activities are small compared with those of other countries. Most investment in R&D is carried out by private firms, a phenomenon not easily understood by western observers. The Japanese ratio of the government R&D expenditure to total national R&D expenditure is 24 per cent, whereas in the United States, West Germany, Britain and France this ratio is approximately 46, 42, 50 and 58 per cent respectively (Kuwahara 1985, p. 55). Government policies in Japan are aimed at strengthening the private sector and not in trying to revivify stagnant industries. Commentators have pointed to the Japanese government programs as complementing the "dynamism and international orientation of the country's . . . firms; they have contributed to, but not created, their competitive ability" (Paul 1984, p. 390).

The reliance on the private sector is an important component of the Japanese industrial strategy. Japanese research and development efforts have traditionally been concentrated in developing process innovations that result in the commercial application of end products. In recent years, Japanese industrial spending in this area has averaged about \$18.8 billion a year (Crane, January 14, 1986). The concentration of research and development on commercial applications, rather than on military considerations or for fostering basic research, has been instrumental in the growth of Japanese high-tech. Analyses comparing the R&D investment patterns of both U.S. and Japanese firms during the 1965-1981 period confirm these observations. It has been found that Japanese firms tended to:

- invest more heavily in applied research and product development projects, rather than in basic research projects;
- invest more heavily in building on pre-existing products and technologies developed by other firms in the same or related industries; rather than in the development of new, unproven products and technologies;
- invest only after specific products or technologies have been sufficiently well developed by other firms, rather than trying to be the first to develop them (Johnson 1985, p. 25).

The electronics industry has been a case in point. Traditionally, this industry has been responsible for one quarter of all R&D spending and has employed a significant proportion of Japanese researchers.

Another important component of the Japanese research policy has been the ability of its well-trained workforce to accept the diffusion of new technologies. The Japanese pride themselves on their ability to obtain foreign technologies and improve upon their applications. The knowledge gained is used to further enhance their own indigenous production processes (process innovation). Furthermore, Japan's industries have been able to look beyond current profit levels, and pay more attention to market share, and research and development activities; details that involve long-range planning horizons and an intimate business-government relationship. Government policies, for example, involve the careful monitoring of:

foreign licensing agreements in order to assure that no domestic firm can thereby gain a monopoly of a particular sector. Where one Japanese firm links up with a foreign company through a technology agreement, the government exerts pressure to have a second or third Japanese firm develop equivalent links with other overseas corporations. This approach has meant greater technology diffusion throughout each industry sector. In addition, the subcontracting system promotes technological diffusion between big firms and small and medium-sized firms, where technological barriers often exist in other countries (McMillan 1984, p. 33-34).

The prominence of research policy in Japanese industrial planning is such that future planning begins with policy formulations today. The key figures in the technology race subscribe to the view that "if they are to have the competitive products and services to provide jobs for the next generation, they must be busy educating people and conducting research today" (Crane, January 14, 1986).

Mechanics for Implementing Research Policy

Japan employs a variety of government institutions that help to formulate strategy for technology and guide the direction of research policy. The Council for Science and Technology (CST) is chaired by the prime minister. This council is the top level body responsible for establishing research and development policy. The council also outlines the direction of scientific research in Japan and is responsible for the coordination of research activities in the various ministries.

The Science and Technology Agency (STA) works closely with the CST and it, too, has fiscal as well as policy responsibilities. The STA prepares a white paper on Japanese scientific trends annually and is fiscally responsible for three public corporations: the Japan Atomic Energy Research Institute, the National Space Development Agency, and the Power Reactor and Nuclear Fuel Corporation.

A key body within the STA is the Research and Development Corporation of Japan, which helps to commercialize the research and development efforts of private and public research laboratories. The corporation fosters contracts and licensing agreements between public and private laboratories, and in 1981 established the Exploratory Research for Advanced Technology Organization (ERATO), which is expected to spend approximately \$70 million during the 1980s to develop innovative technologies.

The Agency of Industrial Science and Technology (AIST) is the branch of the Ministry of International Trade and Investment (MITI) that oversees industrial research and development. It runs 16 national research laboratories staffed by 3,500 researchers, and provides grants and loans for the development of technologies.

MITI's science and technology budget in 1986 was about \$1 billion, which is linked to private sector efforts in order to maximize productive results. One of the most important programs of the agency is the "Project of Basic Technology for Future Industries," whose purpose is to develop the basic technologies "essential to the establishment of new industries which are expected to flourish in the 1990s" (Crane, January 14, 1986).

The Centre for Research Facilitation of Fundamental Technologies is yet another major MITI project to help stimulate basic research in industry. The centre provides low cost funds and equity to industry for approved projects, and its emphasis is to persuade private industry to do more research. The centre has been launched with a budget of about US\$95 million a year to provide to industry.

Although much of the emphasis in research policy is placed on big corporations, small and medium businesses in Japan employ nearly 80 per cent of industrial workers. These are businesses with capital of \$500,000 or less or with fewer than 300 employees, and they account for just over half of manufacturing shipments. MITI is anxious to see these businesses develop better technology, increase their use of information equipment, enhance their employee and management skills, move into new areas and become more active in foreign trade and investment. To facilitate the growth of these businesses, MITI has established the Small and Medium Enterprise Agency, whose job is to strengthen small and medium enterprises.

Japan offers, like Canada, a lower corporate tax rate for small businesses, provides rich tax incentives or tax credits for small and medium companies acquiring high-tech production equipment such as robots, computer-controlled manufacturing systems and distribution equipment, and has three government-affiliated financial institutions which provide cheap loans for business expansion and improvement. In 1984-1985, the three agencies lent more than US\$24 billion (Crane, January 14, 1986).

The Japanese government owns a major financial institution and therefore can more readily direct the allocation of capital funding. The Japan Development Bank provides debt and equity financing to corporations for capital investment and research and development in industries specified by cabinet.

Management-Labour Relations

The dynamic change in Japan's industrial structure, from the labour-intensive manufacturing industries of the late 1950s to the knowledge-intensive, high-tech industries of the 1980s, has depended on a workforce that is capable of changing direction according to where government and business believe Japan can be competitive. For Japanese management and workers to produce innovative products and processes, continual training and retraining is necessary to Japanese industrial strategy. Research and education policy can be seen as a very important means of enhancing Japan's international competitiveness.

Japanese business operations are flexible to accommodate and initiate change. In general, the Japanese corporation is unlike many European and North American corporations in that it does not remain a giant in only one area, but continually penetrates new markets and develops new products. One aspect of this corporate structure is that employees displaced from a declining activity can be shifted to another job within the same company.

...[the] shift in Japanese structure has largely occurred not because new companies exploited new frontiers while existing companies remained in the established fields, but rather because each company exploited new frontiers and shifted from traditional fields to new fields. For example, Toray Industries and Toho Rayon, previously major textile companies, have grown into comprehensive fine chemical companies (Kuwahara 1986, p. 52).

The information industry in Japan has also developed along these lines.

This penetration of new markets is a continuing process in Japan and for it to remain a feasible strategy, managers and employees must continually retrain. Japanese corporate strategies are not determined by top-down, decision-making structures, but rather decisions are often made at the bottom, with the employees, and are funnelled upwards to top management.

Because of its bottom-up decision system and indigenous management, Japanese top management generally does not interfere in technically detailed R&D programs. Moreover, top management even avoids taking the initiative in corporate planning (including R&D strategies). Corporate planning starts with knowing the present state of the company, then proceeds to identify deficiencies and imbalances between factors, and, finally to attempting to correct those deficiencies and to re-establish the balance. Corporate goals are either stated vaguely or in terms of corporate ethos rather than in business terms (Eto 1985, p. 156).

The work group is the fundamental building block of Japanese industry. The group determines what is feasible and what new processes can be developed.

For the Japanese, independence in an organizational context has negative connotations; it implies disregard for others and self-centeredness. . . . The work group is the basic building block of Japanese organizations. Owing to the central importance of group efforts in their thinking the Japanese are extremely sensitive to and concerned about group interactions and relationships (Pascale and Athos 1981, p. 198).

Retraining programs are a fundamental aspect of the Japanese work ethos. It is a function that strives to make the Japanese worker a knowledgeable and integral part of the organization. The Japanese believe that creative modification of existing processes is where their strengths lie. They believe that innovation of this type can be a group effort involving all employees, rather than being left to scientists in a laboratory. For innovation to occur, the group must work together. McMillan (1984) notes that:

the Thomas Edison stereotype of the creative individualist has long since become obsolete in high value-added industries of the future where Japan wishes to excel— aerospace, biotechnology, pharmaceuticals and information. Even in the U.S., most industrial research in these fields is team orientated and organizationally based, precisely the areas where Japanese have major strengths (p. 115).

Education policy is intimately linked with research policy. Learning and know-how are highly emphasized, and Japanese management continues to stress this process. In an attempt to develop sectors with growth potential, "the emphasis is on knowledge-intensive sectors with high value-added and export potential" (McMillan 1984, p. 95). An important factor in the technological advancement of Japan has been its ability to use an effective education policy to create a societal and cultural background different from that of the western world. Many factors contribute to this unique work ethic, factors that are strengthened by a continuing education and retraining policy. First, Japan has developed a highly motivated labour force that continually strives to achieve high-quality production. This has been achieved by providing opportunities for the labour force to participate in management in the form of quality control circles. The Japanese have emphasized this quality control concept as a means of continually increasing productivity.

There is a continuous critical effort at all times to improve quality. One result of this is that products can be sold on quality of performance. It is interesting to note that the continual search for ever higher quality has led to higher productivity and lower costs, with a more relaxed and contented labour force (Prentice 1984, p. 27).

Quality control in Japanese industries invariably begins with the process of training both managers and workers. The idea has developed from the labour-management relationship in which labour is considered a capital investment. The concept of building quality into the work force is but a natural progression to maintaining quality in manufactured products.

Robert Reich, whose views have been shaped by Japan's experience, has emphasized the importance of labour-management relationships:

The success of modern Japan, in particular, seems to contradict Max Weber, the German sociologist, who

attributed the West's economic progress to the demise of traditional relations like guilds, parishes, and clans and to the simultaneous rise of individualism. Japan's emphasis on community, consensus, the long-term security for its workers—based squarely on traditional communal relationships—appears to have spurred its citizens to greater feats of production than has the rugged individualism of modern America (Reich 1983, p. 16).

.... A social organization premised on equity, security, and participation will generate greater productivity than one premised on greed and fear. Collaboration and collective adaptation are coming to be more important to an industrialized nation's well-being than are personal daring and ambition (Reich 1983, p. 20).

Reich places great emphasis on what he terms "flexible-system production." The era of standardized mass production is disappearing in the Western world, largely because newly industrialized countries (NICs) are able to manufacture at much lower costs. In its place has come a demand for commodities that are unique or that have small production runs. In Reich's opinion, such commodities require innovation as well as special skills. All workers must be involved in the development of the product. The traditional corporate command structure cannot respond quickly or appropriately enough to customers' specialized needs. New patterns of corporate organization are necessary, Reich argues—patterns that foster entrepreneurial attitudes among all workers.

Other advanced nations may be compelled to copy Japan in developing this active involvement by labour in the innovation process. In his book, *How American Business Can Meet the Japanese Challenge*, Ouchi (1981, p. 50) has gone so far as to claim that in Japan "nothing of consequence occurs as a result of individual effort." The participative approach to decision-making requires the exploration of alternative solutions by managers and production workers until a consensus is reached. This process minimizes the role of middle management by bringing senior management into direct contact with the workers.

Many Western corporations are attempting to introduce some elements of the Japanese approach and to instill in production workers more feeling for their company's objectives and success. As discussed above, "quality circles" require groups of employees to develop new techniques to improve the quality of the product being manufactured. The expansion of profit sharing is based on a hope that

production workers will be more conscientious and creative so that their firm will benefit.

Some authors, like Reich, believe that a basic change in social attitudes and in government intervention will be necessary in other countries to attain Japan's pervasive entrepreneurial initiative. Rugged individualism must be replaced with group decision making and consensus; laissez-faire capitalism must be replaced with a much greater commitment to education, retraining and adjustment assistance.

The preparedness of the Japanese worker to change jobs is another factor that serves to illustrate the significance of Japanese education policy and how it has become an integral component of industrial strategy. Technological innovation is something that labour responds well to in Japan. Whereas the North American and European worker is ambivalent, or even opposed, to the introduction of new technology, in Japan, workers are prepared to adjust continually. A major reason behind western animosity to such new technologies is the fear of being displaced from employment; the Japanese on the other hand, regard new technology from a more positive perspective, as the basis of future international competitiveness.

Preparing for the 21st Century

In preparing for the 21st century, the Japanese will have to shift from process innovation, based on the modification of foreign technologies, to more original innovation, based on indigenous Japanese inventions. The future expansion of Japanese technology exports to advanced industrial countries hinges primarily on Japan's success in fostering and increasing its indigenous science and technology capabilities. Without this pull in scientific and technological innovation, Japan will find it extremely difficult to compete successfully against other advanced countries.

Japan still lags behind the United States as a technological innovator, and it will be innovation and not adaptation, that will determine the future economic leaders. Industrial policies are still primarily based upon the acquisition and improvement of technology from abroad, and the export of high technology products to other advanced economies remains weak. "Only about a third of Japan's technological export earnings come from other advanced countries; two thirds is still earned from selling adapted technology to Third World nations" (Meeks 1986, p. 155). Export earnings from the advanced industrialized countries should rise if Japan can facilitate its ability to be innovative.

Several authors point to the many shortcomings in Japan's industrial structure that must be overcome if Japan is to maintain a competitive position. First, in an attempt to foster greater innovation, Japan will have to rely increasingly on indigenous scientists and engineers to be more innovative. The present reliance on imported technology will become increasingly difficult to maintain because many western firms are now protecting their advanced technologies "through clauses on equity control, crossed licences, or agreements to divide out third markets" (Arnold 1986, p. 182). Furthermore, the Reagan Administration has attempted to curtail much of the flow of advanced technologies to Japan. According to Kazuo Miyazawa, director of MITI's Supercomputer Project, the technological boycott is beginning to create problems.

It is getting harder to follow leading-edge American technology because the Pentagon often requests American scientists to withdraw sensitive papers from international conferences and has closed many American conferences to foreigners altogether. We are concerned about this stifling of scientific exchanges (Tatsuno 1986, p. 43).

MITI has recognized that a lack of indigenous creativity in the high technology sector could seriously damage Japan's economic standing in the future. Although projects such as the fifth generation computer are an attempt to foster more creativity and innovation, MITI, and two of its agencies (AIST and STA) have launched programs to bridge the innovation gap that is developing between the United States and Japan.

Second, although Japan's list of full-time researchers is impressive, there are still shortcomings. Although Japanese scientists and engineers are well trained, they are still predominantly oriented towards process innovation and thus have not been able to foster the innovative spirit or creative synergism that can be found, for example, in Silicon Valley or Boston's Route 128.

Third, Japan's research and development patterns may also need reform. As illustrated earlier, the private sector figures most prominently in fostering research and development, and this group has emphasized better production processes with a view to commercializing research and development activities. As an imitator, big business in Japan has continually placed priority on production. It took for granted that new designs and knowledge could be imported from abroad and that its researchers could improve upon foreign technology. As can be seen, most research personnel in Japan are assigned this task.

Outstanding college-educated engineers are assigned in large numbers to production lines. Many manufacturing industry executives are engineers who were trained on the shop floor. Even researchers are found more in factories than in research centres. Hitachi is the largest electronics company in Japan and has about 8,000 R&D staff members, only 3,000 of whom work at its research center. The remaining 5,000 are distributed among various factories and operational divisions (Shishido 1985, p. 204).

The private sector in Japan has elevated applied research at the expense of basic research at a time when many feel that the ground-breaking technological innovations occur in basic research. In the United States, the emphasis is placed on the discovery of new technologies and new products. In Japan, the emphasis is placed on finding ways of reducing the costs of products developed abroad. In comparing the two systems, one can clearly see the emphasis placed on process innovation (Japan) and product innovation (U.S.).

Shortages in funding have also limited the ability of Japanese universities to pursue basic research.

America's leading high-tech regions are noted for their top-flight research universities, such as Boston's MIT, Silicon Valley's Stanford University, and Austin's University of Texas, which have strong ties with local industry. However, in this area [Japan is] severely handicapped. Japan has strong national universities in Tokyo, Kyoto, Osaka, and other major cities, but its regional universities are weak compared to American state universities. Not only do they lack adequate laboratory facilities and equipment because of insufficient funding, but they receive few donations from Japanese companies, which often hold these universities in low regard. Most Japanese firms train researchers in-house and focus on immediately commercializable research. When they donate money, they often fund chairs in foreign universities to buy goodwill. As a result, there are few technology exchanges with local universities (Tatsuno 1986, p. 203).

However, in Japan, the universities may be just as much to blame as the corporations.

Japanese universities maintain a strict hierarchy that discourages independent research and outside consulting with industry. Most graduate researchers must conduct

their work under the auspices of a department head and cannot claim inventions or patents in their own names. As a result, innovative projects are often stifled and basic research goes ignored (Tatsuno 1986, p. 203).

The emergence of newly industrializing countries challenging Japan's competitive advantage in some high technology areas will force Japan to concentrate on capitalizing further on technologies in which it has a comparative advantage, and areas where the potential for new market penetrations exists. "Government ministries . . . [will have to] anticipate, cultivate, and promote emerging technologies and markets in which Japan has a competitive advantage. Anticipation, not reaction, will be the name of the game, and government's new role will be that of catalyst, strategist, cultivator, and adviser — a cross between think tank and a consulting firm" (Tatsuno 1986, p. 35).

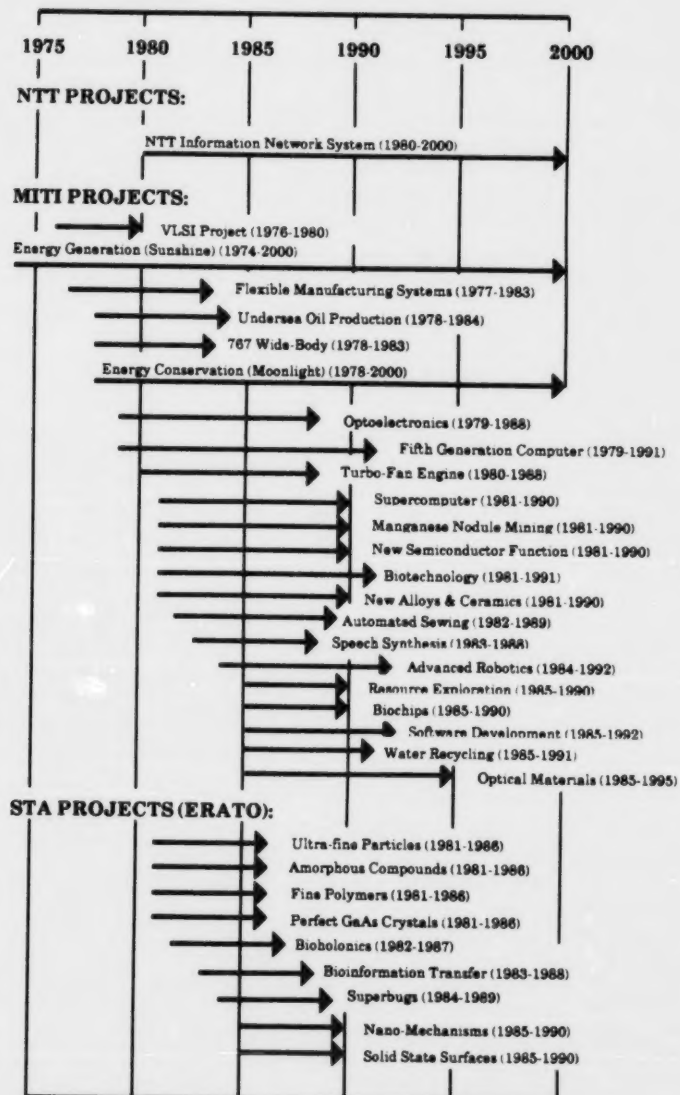
Future process innovations alone will not be sufficient to maintain a competitive position in the international economy. The newly industrializing countries are quickly overtaking Japan in application technology.

Sheridan Tatsuno, author of *The Technopolis Strategy*, discusses several strategies that the Japanese government is implementing in order to guide Japan into competitiveness in the twenty-first century. Five such strategies that directly relate to the fostering of entrepreneurship and innovativeness of Japan are: Parallel-Track R&D Projects; Strategic International Alliances; The Technopolis Concept; Telecommunications Networking; and Venture Capital and Venture Business programs. To better understand Japan's adjustment policies, it will be useful to examine each of these strategies in further detail. Unlike the Japanese practices of the past, these strategies are not based on protectionism or large budget increases in the research and development effort.

Parallel-Track R&D Projects

Joint R&D projects are being undertaken in the government and private laboratories and are geared to developing innovations in computers, semiconductors, jet engines, biotechnologies, new alloys, robotics, communication satellites and solar energy, to name but a few. As previously mentioned, MITI's fifth generation computer is an example of this type of project with a high profile status. However, as can be seen from the following diagram, it is only the tip of the iceberg.

Parallel-track projects have a long planning horizon, focus on the development of competition between the participants and are designed to foster a synergism between the research teams. As the



Source: Tatsuno, Sheridan (1986) *The Technopolis Strategy: Japan, High Technology, and the Twenty-first Century*. New York: Prentice Hall Press.

illustration shows, all the research projects are in one way or another directly related to each other. By placing projects that are related to each other on the same planning horizon, Japan hopes to create an exchange of ideas and processes between the various undertakings in order to foster the development of all projects.

Several agencies are involved in the sponsoring of these projects. They include MITI, the Science and Technology Agency (STA), Nippon Telegraph and Telephone (NTT), the Ministry of Posts and Telecommunications, the Ministry of Education, and the Ministry of Construction.

As a further step in helping to promote innovation through parallel-track projects, MITI has opened its research laboratories to the small, innovative companies in Japan that are capable of producing leading-edge technologies. These companies, styled on many of the U.S. venture businesses, had been excluded from the public research and development efforts of MITI and the accompanying agencies. These small innovators were often too small and too fiscally restricted to undertake broad R&D efforts on their own initiative. MITI has sought to address this problem by offering R&D subsidies and tax breaks to these small entrepreneurs, and is integrating their capabilities into the national research and development effort.

Strategic International Alliances

In an attempt to maintain access to the key advanced technologies of the West, access that in the last few years has been restricted, Japanese corporations are beginning to alter their strategies. Joint research and mutual technology exchanges with other nations are tactics that the Japanese are employing to guarantee that the flow of technology does not lapse. The international economic environment is becoming so competitive that governments and companies are beginning to use advanced technology as a bargaining chip, in exchange for competitive advantages in other economic fields. To overcome this dilemma, the major technology agencies—MITI, the Science and Technology Agency, and Nippon Telegraph and Telephone—are pursuing international alliances in three areas: "high-technology working groups, MITI and NTT research projects, and technical information exchanges." For example, at the June 1982 Versailles Summit,

Japan participated with Canada, France, West Germany, the United Kingdom, and the U.S. in setting up a Working Group on Technology, Growth, and Employment. The Working Group proposed twenty-two international

collaborative projects in high-technology research, four of which Japan agreed to organize: safety research on light water nuclear reactors, photovoltaic solar energy, photosynthesis, and advanced robotics. Japan is using these projects to keep in touch with the latest developments in the West (Tatsuno 1986, p. 43-44).

The complexity of acquiring up-to-date technology in the future will force Japan to encourage more strategic alliances so it can maintain technological and international competitiveness.

The Technopolis Strategy

This third strategy revolves around Japan's efforts to foster the growth of 19 new technology centres being built along the same lines as the California Silicon Valley, Boston's Route 128, and the Research Triangle in North Carolina. In pursuing this strategy, Japan hopes to emulate the business-university-government connections of the U.S. research centres. What has been described as the "Japanization of Silicon Valley" is an attempt to "adopt the best features of American's high-tech regions to a uniquely Japanese model of high-tech development" (Tatsuno 1986, p. 50).

Telecommunications Networking

Nippon Telegraph and Telephone (NTT) plans to transform the telecommunications system into an Information Network System (INS). It is envisioned that by 1995 Japan's major cities will be linked with the technopolises by a nationwide fibre optics network that will replace the antiquated telephone lines that have been in place since World War II. The goal of INS is to upgrade Japan's telecommunications network through the use of communications satellites, supercomputers, including the fifth generation computers, and video signal processing. The INS program is designed to provide Japan with the most advanced telecommunications system in the world. Not only will the new telecommunications market boost NTT's revenues but, more important, it will also facilitate the development of future high-tech industries. For example, in satellite technology, NTT, the Japan Broadcasting Corporation, and Japan's National Space Development Agency (NSDA) are working with a \$470 million budget to develop new satellite systems. Nippon Telegraph and Telephone will invest \$125 billion to \$150 billion into the INS project over the next 20 years and expects to create a \$200 billion to \$300 billion market for new telecommunications services in return (Tatsuno 1986, p. 52).

Venture Capital and Venture Business

In an attempt to foster entrepreneurship, Japan is making great efforts to extend its capital market in ways that will facilitate the growth of new venture businesses. As mentioned, Japan is trying to shed its imitative image and foster an entrepreneurial environment to attain a greater innovative capacity. MITI has offered incentives to these companies, for it views them as a source for future economic growth.

According to MITI's 1983 White Paper on Small and Medium Enterprises in Japan, changes in the economic environment - notably in the demand structure and the progress of technological innovation - have dictated that serious attention be devoted to the promotion of venture businesses, which is regarded as a vital cog in efforts to reach the technological frontiers of the twenty-first century. In recent years, the Japanese government has realized the importance of venture business in the present era of diversified demand and rapid technological change (Yoshikawa and Woodall 1985, p. 703).

As investments shift away from declining heavy industries, Japan is finding a greater proclivity for investors to invest in start-up high-tech companies. The rapid growth of the high technology sector in Japan has fostered an investment boom, and this has been stimulated by a November 1983 Ministry of Finance decision to create three over-the-counter (OTC) markets at the Tokyo, Osaka, and Nagoya exchanges.

According to MITI's Venture Capital Research Group, venture capital investments in high-tech ventures jumped from \$10 million to \$160 million in 1983. Foreign venture capital firms invested about \$40 to \$80 million of this amount (Tatsuno 1986, p. 60).

Prospects for Japan in venture business are promising. The influx of American venture capitalists, the creation of an OTC stock market, growing entrepreneurship among the Japanese, and the high-tech boom should provide a strong impetus for the venture capital market in Japan.

Conclusion

Education and research policies have played a significant role in Japan's high-tech strategy. In particular, these policies have been increasingly relied upon as a mechanism for facilitating adjustment. High R&D expenditures as a per cent of GNP, a private sector that is capable of increasing its involvement in the high-tech industries, and the rapid diffusion of technology are important aspects of Japan's success. As this book has repeatedly noted, the high-tech emphasis on flexible business operations requires a well educated workforce. Japan has achieved this objective through programs that provide for continual retraining and through its unique labour-management relationship. The institutional mechanisms through which education and research policies are developed and coordinated are also important components of Japan's competitiveness. Today's emphasis on new commodities and small production runs requires constant innovative capacity and an advanced level of skill specialization. Japan's ability to foster an entrepreneurial attitude among its workers is a facet of research and education policy which other nations are seeking to emulate. Examination of Japan's education and research policies demonstrates the importance of these as a basis for competitive adjustment in our new world economy.

Chapter XV

Canadian Education and Research Policies

Introduction

This chapter examines the Canadian record in education and research. At first glance, the statistics create a favourable impression. Over the 25-year period 1960-1985, university enrolment of both full-time and part-time students rose substantially. Over the period 1971-1986, gross domestic expenditures on R&D in constant dollars (1981) nearly doubled.

Nevertheless, a number of disquieting elements blot this Canadian record. Over the 1979-1985 period, operating grants to universities have declined in real terms by over 20 per cent on a per student basis. Significant variations exist across provinces; per student operating grants are particularly low in Nova Scotia, Prince Edward Island, and New Brunswick. Capital expenditures on university facilities have declined over the past 15 years. The number of earned Ph.D. degrees climbed dramatically until 1972, but have remained constant since then. Ph.D. enrolment in natural and applied sciences fell 25 per cent over the decade of the 1970s. While Canadian research and development has climbed, nevertheless, Canada's relative R&D input ranks far below other OECD countries.

A number of federal and provincial programs allocate public funds to corporate R&D activities, and Chapter XV describes some of these. Of special interest are new programs that seek to foster joint corporate-university research. Meanwhile, the programs that allocate public funds to the retraining of employees are placing a greater

emphasis on retraining within corporations rather than in formal educational institutions.

The Funding of Educational Institutions

Number of Students

In 1985 provincial ministers of education issued a document summarizing the post-1960 Canadian enrolment record. They described the "dramatic" increase in students over the past 25 years:

Since the early 1960s, the expansion of post-secondary education systems in Canada has been dramatic. Indeed, some would call it revolutionary.

In 1960-61, there were 114,000 full-time students in Canadian universities. By 1981 that number had increased to 402,000 and estimates for 1984-85 indicate that full-time enrolments now stand at 461,000. Thus, over a twenty-five year period, full-time university enrolments have increased by some 300 per cent, with much of that growth coming in the eighties. Part-time university enrolments have also increased enormously – from 65,000 in 1965-66 to some 276,000 by 1984-85, an increase of over 300 per cent in less than twenty years. When this is added to the almost equally dramatic increase in full-time college enrolments (from 166,000 in 1970-71 to 330,000 in 1984-85), one begins to appreciate the enormous growth in post-secondary educational opportunities which has taken place over the past twenty-five years (Canada, Council of Ministers of Education Canada, 1985, p. 3).

In an article in 1985, Joel Novek compared this Canadian record with the experiences of other countries. Novek focused on the percentage of the labour force holding university degrees. He concluded that Canada ranked second in the world, with 10.5 per cent of our labour force holding degrees. Only the United States has a higher percentage.

Population Projections

An important question concerns the capacity of Canada's present post-secondary system in view of population projections. Any expansion of the system would require several years, since new structures and equipment would need to be built, new equipment would need to be

constructed, and new faculty would need to be educated and hired. Planning would have to be done now for any capacity expansion to be ready by the 1990s. In this regard, the Royal Commission on the Economic Union and Development Prospects for Canada projected in 1986 that, by the mid-1990s, Canada's 18-to-24-year group will number 2.6 million people, representing a reduction from the present 3.3 million. From this perspective, we can forecast excess capacity in the 1990s if participation rates remain constant.

Differences Among Provinces

Our presentation of data to this point has considered Canada as a whole. It is important to note, however, that significant differences exist among its provinces, differences that have been emphasized dramatically by Thomas Symons (1985), who concludes that Canadian students do not experience equality of educational opportunity. The picture of Canadian success that we have presented based on national data breaks down when we turn to data by province:

Significant differences in the quality and extent of post-secondary opportunity available to young Canadians are also indicated by the disparities in expenditures, on higher education on a per student basis as well as on a per capita of population basis. In 1982/3, expenditures per full-time equivalent (FTE) university student varied from about \$6,700 in P.E.I., \$6,900 in Ontario, \$7,000 in New Brunswick, and \$7,100 in Manitoba, to \$9,000 in Alberta and \$9,500 in British Columbia. Expenditures on university education per capita of the total provincial population varied from approximately \$97 in P.E.I., \$132 in B.C., and \$145 in New Brunswick, to \$205 in Nova Scotia.

Such disparities are even more pronounced at the community college level of post-secondary education. In 1982/83, expenditures per full-time student varied from approximately \$5,500 in Quebec and \$6,300 in Ontario to \$14,200 in New Brunswick and \$14,700 in Saskatchewan. Expenditures on college education per capita of the total provincial population varied from approximately \$20 in Manitoba and \$21 in Nova Scotia to \$126 in Quebec.

There are also notable disparities in the tuition fees charged to Canadian university students depending on the province in which they study. A student in arts, in 1983-1984, paid fees of approximately \$500 in Quebec but more than double that amount, approximately \$1,200 in Nova Scotia. Tuition fees in other provinces varied widely over

the range between these two extremes. Similar disparities between provinces in tuition fees existed in other academic areas, including agriculture, architecture, commerce, dentistry, education, engineering, household science, law, medicine, music, science, and graduate studies.

The discrepancies that now exist across the country in the public support given by the provinces to education, including post-secondary education, are so great that they can only lead to serious and regrettable differences in the education, cultural, social, and economic opportunities available to Canadians. They point to profound inequities in our education system. The Council of Ministers of Education in Canada (CMEC) may have achieved some kind of equality for ministers of education, but they have done little to achieve equality of opportunity for students across Canada (Symons 1985, p. 266).

Government Expenditures

Government expenditures on education as a percentage of gross national product (GNP) provide another perspective on this record. International comparisons of this nature include all levels of education. Novek (1985) found that Canadian public expenditures on education in 1980 represented 7.3 per cent of GNP, the second-highest of the countries in the Organization for Economic Cooperation and Development. Only Sweden spends a higher percentage of its GNP on education (Novek 1985, p. 186). Additional evidence is the comparison of recent government university operating expenditures with the expenditures over the 1974 to 1985 period. Here one finds a significant decrease in operating expenditures per student for Canada as a whole. As Table 15.1 indicates, Alberta, Quebec, and Newfoundland have experienced increases. But the other provinces have all suffered a decrease in operating grants per student. For example, the Ontario government's operating grants per university student have fallen in real terms by about \$770 in 1981-1982 dollars, about 16 per cent.

The capital expenditures picture is more complicated. Expenditures in the 1960s and 1970s were often directed at physical expansion to accommodate larger enrolments. Changing demographic patterns place different demands on capital expenditure at different times. Nevertheless, some evidence exists that plant and equipment expenditures have not kept up with today's needs.

The deterioration of buildings and equipment is difficult to quantify but two perspectives may be helpful: first, a Council of Ontario Universities (COU) analysis concerning the average age of

Table 15.1
Interprovincial Comparisons of Operating Grants to
Universities Per FTE* Student 1974-75 to 1984-85
(in 1981-1982 dollars)

	1974-75	1975-76	1976-77	1977-78	1978-79	1979-80
British Columbia	5527 (4)	5942 (4)	6297 (4)	6477 (3)	6685 (3)	6422 (3)
Alberta	6184 (1)	6733 (1)	6778 (1)	6872 (2)	7017 (2)	6998 (2)
Saskatchewan	5432 (5)	5664 (5)	5858 (5)	5885 (5)	6066 (5)	6135 (5)
Manitoba	4735 (8)	5010 (6)	5370 (6)	5534 (7)	5419 (7)	5741 (6)
Ontario	4909 (7)	4839 (8)	5078 (8)	5256 (8)	5259 (8)	4982 (9)
Quebec	5578 (3)	6233 (3)	6344 (3)	6374 (4)	6120 (4)	6377 (4)
New Brunswick	4954 (6)	4988 (7)	5358 (7)	5595 (6)	5735 (6)	5730 (7)
Nova Scotia	4436 (9)	4711 (9)	5028 (9)	5010 (9)	5018 (9)	4903 (10)
P.E.I.	4405 (10)	4301 (10)	4425 (10)	4341 (10)	4657 (10)	5110 (8)
Newfoundland	5619 (2)	6327 (2)	6465 (2)	6626 (2)	7208 (1)	7213 (1)
Canada	5239	5518	5734	5870	5854	5824
	1980-81	1981-82	1982-83	1983-84	1984-85	
British Columbia	6150 (4)	6205 (2)	5655 (2)	5019 (4)	4430 (5)	
Alberta	7316 (1)	7126 (1)	6944 (1)	6638 (1)	6277 (1)	
Saskatchewan	5740 (5)	5414 (5)	5418 (4)	5128 (3)	4896 (3)	
Manitoba	4869 (6)	4881 (6)	4728 (6)	4654 (6)	4401 (6)	
Ontario	4624 (10)	4315 (10)	4251 (10)	4194 (9)	4141 (9)	
Quebec	6423 (2)	5954 (3)	5349 (5)	4872 (5)	4723 (4)	
New Brunswick	5334 (7)	4820 (7)	4647 (7)	4367 (7)	4233 (7)	
Nova Scotia	4739 (9)	4733 (8)	4479 (8)	4133 (10)	3876 (10)	
P.E.I.	4806 (8)	4552 (9)	4429 (9)	4307 (8)	4213 (8)	
Newfoundland	6152 (3)	5638 (4)	5504 (3)	5914 (2)	5207 (2)	
Canada	5629	5330	5043	4773	4580	

*FTE includes the part-time students at their full-time equivalents.

Source: Tripartite Committee on Interprovincial Comparisons, April 1985, for actual data. COU Research Division for estimates.

Ontario university structures; and second, a comparison between capital grant recommendations of the Ontario Council on University Affairs (OCUA) and actual capital grants in Figure 15.1. In its brief to the Bovey Commission, the Council of Ontario Universities (COU) (1984) stated that in 1975-1976 more than 60 per cent of physical plant was less than 10 years old. By 1983-1984 this proportion had fallen to less than 14 per cent. Meanwhile the 14 per cent of plant that was 20 years old or more had increased to more than 27 per cent. It goes on to say:

Evidence suggests that operating costs of physical plant increase significantly with age. Total operating costs per year (for privately owned office buildings in major Canadian cities) were about 50 per cent greater for buildings 20 to 29 years old than they were for buildings less than 10 years old. The disparity between relatively new and old buildings is greatest for the costs of building repairs and maintenance. The Building Owners and Managers Association data suggest that a building over 20 years old will have repair and maintenance expenses more than double those of a building less than 10 years old. In addition, cleaning, utilities, and security all will be more costly for older buildings (COU 1984, p. E8).

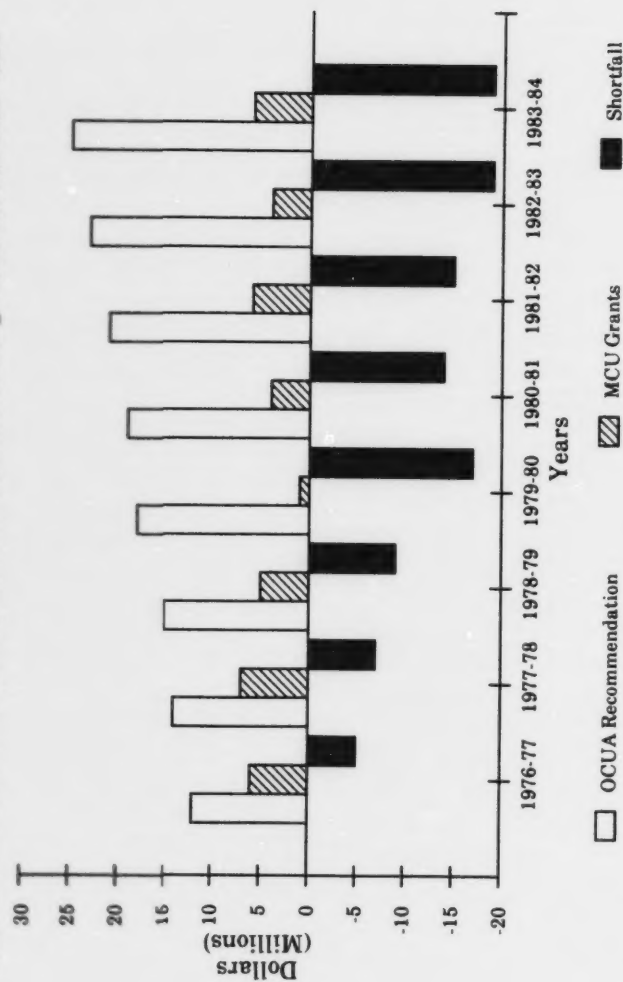
"In real terms capital grants to Ontario universities fell from almost \$99 million (in 1982-1983 dollars) to less than \$10 million in 1983-1984. In other words, over a period when demands on the capital stock rose very substantially, the capital funding of Ontario universities fell to a tenth of its previous value" (Dowd 1985, p. 349). The following figure reveals the huge gap between OCUA capital funding recommendations and the actual capital grants of the Ontario government.

As Table 15.2 indicates, capital expenditures as a percentage of total expenditures fell significantly over the years 1960-1961 to 1982-1983, both for Ontario and Canada as a whole. In constant dollars, Ontario has experienced a particularly severe drop in capital grants, as Table 15.3 reveals.

The Funding of Research Within Educational Institutions

Our discussion in Chapter XIII emphasized that formal institutional education is intimately linked with scientific research. Expenditures by universities cannot be divided with much precision between teaching and research: faculty time is devoted to both; buildings and

Figure 15.1
OCUA Capital Funding Recommendations for Major Repair, Renovations and Replacement Projects, Government Grants, and Shortfall in Funding: 1976-1977 to 1983-1984



Source: Ontario, Council on University Affairs. *Eleventh Annual Report*. Toronto: Council on University Affairs, March 1985, p. 43.

Table 15.2
Capital expenditures as a percentage of total expenditure:
Ontario and Canada, 1960-1961 to 1982-1983

	Ontario	Canada		Ontario	Canada
1960/61	36.1	30.4	1972/73	15.4	14.3
1961/62	31.8	28.7	1973/74	15.2	12.4
1962/63	29.8	31.6	1974/75	6.4	9.1
1963/64	35.6	33.5	1975/76	4.7	9.0
1964/65	40.5	38.7	1976/77	3.6	6.0
1965/66	42.5	36.8	1977/78	4.6	7.0
1966/67	39.9	35.8	1978/79	2.8	7.2
1967/68	34.6	33.6	1979/80	2.3	7.2
1968/69	32.7	27.3	1980/81	4.0	7.3
1969/70	28.7	24.7	1981/82	2.9	6.8
1970/71	27.1	24.3	1982/83	4.0	7.5
1971/72	19.1	18.8			

Note: 1981/82 and 1982/83 data is unpublished information received from Education Finance Sector of Statistics Canada.

Source: Dowd, Kevin. "The Capital Funding of Ontario Universities: What Should be Done?" in *Ontario Universities: Access, Operations and Funding*. Toronto: Ontario Economic Council, 1985, p. 350.

Table 15.3
Capital grants to Ontario Universities,
1972-1973 to 1983-1984

	Constant (1972/73) dollars		Constant (1972/73) dollars
1972/73	98,712	1978/79	10,365
1973/74	50,079	1979/80	10,618
1974/75	17,840	1980/81	10,074
1975/76	15,627	1981/82	9,921
1976/77	12,372	1982/83	11,790
1977/78	16,863	1983/84	9,723

Source: COU (1984) p. E-18.

equipment are used for both. While the data presented in the preceding section retain their relevance, we can find additional data and expert commentary that do cast more light on this aspect of the Canadian research record.

For example, Ontario's 1984 "Commission on the Future Development of the Universities of Ontario" (Bovey Commission) emphasized that Ontario universities had enjoyed a "dramatic" increase in research funding.

Research funding from all sources which amounted to \$9.4 million in 1961-1962 had by 1982 reached approximately \$274 million. When corrected for inflation, this is more than an eight-fold increase. In 1982, Ontario universities, in a province with approximately 35 per cent of the total Canadian population, accounted for 41 per cent of all sponsored university research. Research in our universities has been marked not only by quantity but by quality, as illustrated by impressive discoveries of fundamental importance over a wide array of fields and the technology

that has evolved from these discoveries (Ontario, Bovey Commission 1984, p. 3).

Current Shortages of Research Graduates

In preparing its first Five-Year Plan, Canada's Natural Science and Engineering Research Council (NSERC) emphasized a shortage of qualified personnel as a basic constraint that it believed would limit its proposed expansion of scientific research. To improve Canada's R&D efforts, NSERC believed that, as a first step, an increase in postgraduate university enrolment was needed.

The National Need for Trained Researchers: It is apparent that any major move to improve the national R&D effort is dependent in the last instance on having the qualified personnel to do the work. NSERC has analyzed the manpower requirements which are associated with the announced goals for R&D by the mid-1980s as well as the probable production of research-trained manpower in the same period. Even with optimistic assumptions regarding postgraduate university enrolment, it is clear that critical shortages of research talent in the 1980s will prevent the attainment of the announced goals (NSERC 1985).

This NSERC position was shared by the Ministry of State for Science and Technology (MOSST). In a 1979 paper, MOSST also emphasized this perspective:

Any major move by the Federal Government to encourage and strengthen our national R&D effort is largely dependent on having the qualified personnel to do the work. Success in raising the level of R&D performed in industry, as envisaged in the GERD target, will be impeded unless there is sufficient skilled, research-trained manpower. Studies by MOSST and NSERC have shown that major increase and restructuring of GERD towards more industrial R&D is likely to be constrained by a shortage of research-trained manpower, largely in the disciplines of engineering and applied natural sciences, but eventually also in business and management studies (Canada, MOSST 1979, p. 10).

Thomas Symons and James Page (1984) emphasize this failure of Canada's educational system.

A further study of research manpower training needs by NSERC in 1982 confirmed that there would be a 10 to 15 per cent shortfall in the annual supply of new graduates at master and doctoral levels in the natural sciences and engineering over the ensuing five years. It found, however, that in the physical sciences and engineering the shortfall per year is approximately 1,000 graduates, or 50 per cent of supply (Symons and Page 1984, p. 182).

From the perspective of corporate needs for educated personnel, the Electrical and Electronic Manufacturers Association of Canada has emphasized a similar concern as recently as March 1986:

Economic well-being depends on industry and trade. This in turn is becoming increasingly dependent on the intellectual and technical competence of the people of the nation. Industry has very serious concerns about the present availability and future development of highly-educated workers, particularly for areas of rapid technological change. Industry is going to need more and better people. In engineering, applied science, commerce, and business we have seen declines in quality over the last decade and fear that without deliberate and strong actions, this deterioration will accelerate and threaten our industries and our economic well-being.

Canada's ability to produce the numbers of engineers and skilled technical people needed for industry to grow is very much in doubt. Also in doubt is whether we can keep pace with soaring levels of scientific skill needed for tomorrow's researchers to be able to successfully position even part of Canada's industry in a highly competitive world market. These are matters of serious concern (EEMAC 1986, p. 1).

In its second Five-Year Plan, released in 1985, NSERC repeated this emphasis on education as a determinant of Canada's success in R&D. This recent analysis raised the following five questions concerning our educational system:

- Are we training enough skilled researchers to achieve our national research and development aspirations?
- Is the training adequate and in the right fields?

- Once we train our researchers, are we then losing large numbers of this national resource to the United States and other countries?
- Can we continue our heavy past dependence on imported research talent?
- Can existing research faculty cope with the combination of decreasing budgets and increasing research and teaching demands? (NSERC 1985, p. 127).

The number of earned doctoral degrees in Table 15.4 is also an illustration of the increased research activity in Canadian universities.

This optimistic view of Canadian university research activity appears to rest on the choice of 1960-1961 as the basis for comparison. Clearly the 1960s did see a phenomenal increase. However, by 1970 this seems to have reached a plateau. While the number of earned doctorates jumped from 306 in 1960-1961, to 1,625 in 1970-1971, the number in 1984 was only 1,890. As Table 15.5 indicates, there was a pronounced and prolonged decline in the number of doctoral students enrolled in Canadian universities in R&D-related sciences throughout most of the 1970s (Symons and Page 1984, p. 107).

International Comparisons

Table 15.6 casts more light on this aspect of the Canadian record. OECD estimates suggest that Canadian university R&D in sciences fell over the 1969-1981 period. This decrease in Canadian university R&D contrasts sharply with the advances in other nations. Sweden experienced an annual increase of 10.3 per cent over this 1969-1981 period, while Japan's annual increase was 6.8 per cent. Canada's 1969-1981 experience was by far the worst.

Despite this decline in research expenditures in real terms over the 1969-1981 period, Canadian universities still had a sizeable share of the 1981 national research effort, namely 21.4 per cent (Canada, MOSST February 1985, p. 27). Table 15.7 presents the 1984 experience by province and by performing sector (federal government, provincial government, business, higher education, and non-profit). It is clear that universities play a major role in our national R&D efforts. Table 15.8 emphasizes this fact by comparing the percentage of Gross Expenditures on Research and Development (GERD) performed by each sector in each of seven countries. Only Sweden, with 27 per cent has a bigger percentage of GERD, performed in its higher education institutions. The United States, at 13.4 per cent, is far behind Canada

Table 15.4
Earned Doctoral Degrees in Canada
1960-1961 to 1984

Year	Number of Doctorates Earned
1960-61	306
1961-62	321
1962-63	421
1963-64	481
1964-65	566
1965-66	696
1966-67	779
1967-68	1,006
1968-69	1,108
1969-70	1,375
1970-71	1,625
1971-72	1,724
1972-73	1,929
1974*	1,896
1975	1,840
1976	1,693
1977	1,702
1978	1,819
1979	1,803
1980	1,738
1981(1)	1,789
1982(2)	1,820
1983(3)	1,860
1984(4)	1,890

*Beginning in 1974 Statistics Canada changed the year basis for the collection of information on Ph.D.s awarded from an academic year to calendar year.

1. Preliminary
2. Estimated
3. Forecast

Source: Symons, Thomas H.B. and James E. Page. *Some Questions of Balance: Human Resources, Higher Education and Canadian Studies*. Ottawa: Association of Universities and Colleges of Canada, 1984, p. 108.

Table 15.5
Ph.D. Enrolment Full-time and Part-time by Major Divisions
1970-1971 to 1981-1982

Years	Division A Humanities and Related Disciplines	Division B Social Sciences & Related Disciplines	Division C Natural and Applied Sciences	Division D Life Sciences	Totals
1970-71	3,088	3,345	4,182	2,199	12,814
1971-72	3,263	3,827	4,066	2,122	13,268
1972-73	3,379	4,169	3,845	1,938	13,331
1973-74	3,401	4,369	3,541	1,810	13,121
1974-75	3,295	4,640	3,352	1,774	13,061
1975-76	3,259	4,934	3,264	1,801	13,258
1976-77	3,084	4,951	3,183	1,808	13,026
1977-78	3,067	5,006	3,112	1,832	13,017
1978-79	3,008	5,102	2,957	1,902	12,969
1979-80	2,777	5,082	2,931	1,910	12,700
1980-81	2,671	5,276	2,962	2,053	12,962
1981-82	2,668	5,319	3,056	2,196	13,239

Source: Symons, Thomas H.B. and James E. Page. *Some Questions of Balance: Human Resources, Higher Education and Canadian Studies*. Ottawa: Association of Universities and Colleges of Canada, 1984, p. 109.

Table 15.6
R&D Resources Devoted to the Higher Education Sector in the OECD Countries:
Levels and Trends (All fields of Sciences)

	In millions current ppp \$1981	Number of Researchers (FTE) 1981	Average annual real growth (in %)			
			69-81	69-75	75-81	81-82
United States	10,648.0	98,700	1.2	-0.9	3.4	-2.9
Japan	6,549.7	163,264(xx)	6.8	8.4	5.2	4.7
F.R.G.	2,670.0	30,229	4.2	6.7	1.8	-2.5
France	1,777.5	32,700	3.9	2.6	5.1	3.4
United Kingdom	1,531.0	"	4.3	7.5	1.2	"
Italy	822.9	24,754	1.8	2.5	1.2	-1.8
Canada	917.7	7,520	-0.5(x)	-2.5(x)	1.6	-0.2
Netherlands	585.9	6,123	3.0	5.3	0.8	"
Sweden	597.0	5,600	10.3	12.6	8.1	"
Switzerland	355.9	"	6.0	6.5	5.5	"
OECD(x)	28,240.0	424,300	3.3	2.9	3.7	"

(x) OECD estimates

(xx) Japan not in full-time equivalent.

Source: Canada, Ministry of State for Science and Technology. *Science, Technology and Economic Development: A Working Paper*. Ottawa: MOSST, 1985, p. 29.

Table 15.7
The Provincial Performance of R&D, 1984
(\$000,000)

Province and Region	Federal Government	Provincial Government	Business Enterprise	Higher Education	Private Non-Profit	Total
Newfoundland	36	1	5	18	-	60
P.E.I.	7	-	1	1	-	9
Nova Scotia	95	4	15	38	1	153
New Brunswick	18	4	13	15	1	51
Atlantic provinces	156	9	34	72	2	273
Quebec	176	40	647	236	22	1,121
Ontario	703	58	1,687	398	35	2,881
Manitoba	112	4	30	55	5	206
Saskatchewan	37	7	41	36	-	121
Alberta	69	42	232	136	1	480
B.C.	84	14	170	92	5	365
Western provinces	302	67	473	319	11	1,172
Yukon & N.W. Territories	-	-	18	-	-	18
Canada	1,337	174	2,859	1,025	70	5,465

Source: Statistics Canada, *Resources for Research and Development in Canada 1985*.

in this respect (although U.S. expenditures in this sector are under-reported).

At this point, it is worthwhile to refer back to Figure 13.1 in which CHEF classified university research expenditures into basic, applied and developmental. For 1984, total university research expenditures of \$1,069 million were divided into \$642 million for basic research, \$296 million for applied and \$131 million for developmental.

Table 15.8
International Comparisons
Percentage of GERD by Performing Sector, 1983

Country	Government Enterprise	Business Education	Higher Non-Profit	Private
U.S.A.	12.3	71.3	13.4	3.0
F.R.G.	13.2	70.7	15.6	0.6
Sweden*	5.3	67.5	27.0	0.2
Japan	9.6	63.5	21.8	5.1
France	26.4	56.8	15.8	1.0
Netherlands	18.8	53.6	24.6	3.0
Canada	26.6	47.6	24.7	1.1

* Natural sciences and engineering only

Source: OECD, "Selected Science and Technology Indicators: Recent results, 1979-1986," September 1986.

Over the past few years, several task forces have attempted to evaluate the adequacy of these expenditures. Each task force has criticized current funding levels in the context of today's increasingly competitive world. Each has advocated greater expenditures. Some, like Al Johnson (1985), have felt that this might be achieved through a rationalization of the system, with more funds being channelled to the better research institutions and less being allocated to those emphasizing general education.

The Corporate-Higher Education Forum has stated bluntly that "the quality of education and research is deteriorating at a time when there is an urgent national need to raise those standards" (CHEF 1985, p. 9). To compete against foreign producers, our technological innovations must rank with the best in the world. To support the capabilities of our labour force, our universities must provide the most advanced training available. Yet, in the words of a 1985 federal government report, "Canada's governments and universities have for too long been preoccupied with a determination to provide a good quality, near-universal, system of university and college education, and not enough with the aspiration to develop world-class centres of excellence within that system . . ." (Johnson 1985, p. 20).

Looking specifically at Ontario, the 1981 Fisher report said that "[i]n the latter part of the 1970s, the research capacity of Ontario universities diminished. The stock of research equipment acquired in the 1960s as part of capital expansion is rapidly becoming worn out or obsolete" (Fisher 1981, p. 15). Similarly, the 1984 Bovey report concluded that "in the interests of both the province and the nation additional support to meet the costs of such research is urgently required" (Ontario, Bovey Commission 1984, p. 7). Yet both of these reports expressed optimism about the additional contribution that Ontario's university research could be providing to meet Ontario's economic and social needs.

1986 Government Initiatives to Support Corporate-University Cooperation

Finance Minister Michael Wilson emphasized in his February 1986 budget speech that "a new partnership between the private and public sectors" was necessary to facilitate the accumulation of knowledge so vital to Canada's future. To encourage and promote the growth of a 'new partnership,' the federal government acknowledged that it had to be a key player "in supporting university-based research and the development of highly qualified personnel" (Budget Speech, February 26, 1986). To accomplish this end, support has been provided for our three Canadian research councils.

One channel for this support is through the operations of the Natural Sciences and Engineering Research Council, the Medical Research Council and the Social Sciences and Humanities Research Council. The government proposes to provide a secure funding base for these councils by adding \$300 million over the balance of the decade.

We are also prepared to increase this base funding up to 6 per cent by matching, dollar-for-dollar, private sector

contributions to the councils. This could provide an additional \$700 million over the next five years. But the partnership created between the private sector and university researchers is just as important as the dollars. Contacts between the business and academic communities would be improved. And Canada would benefit from the more vigorous and coordinated application of scientific knowledge to our industrial needs (Budget Speech, February 26, 1986, p. 19).

In addition to this federal government initiative for corporate-university co-operation, Premier David Peterson has announced the establishment of \$1 billion technology fund to encourage further linkages in the corporate-university relationship in Ontario.

The technology fund will support a wide variety of initiatives and joint ventures, some of them involving partnerships with the federal government, universities and the private sector. This Budget sets aside \$100 million this year as our initial contribution towards these initiatives (Ontario Budget 1986, p. 4).

Canadian R&D Expenditures

The preceding sections provide useful insights into the Canadian R&D record. Table 15.8 shows that business R&D in 1983 constituted 48 per cent of total Canadian R&D and government R&D constituted 27 per cent. Figure 13.1 indicated that of the 1984 total business R&D of \$2,673 million, only \$203 million was spent on basic research, while \$1,005 million was spent on applied research, and \$1,465 million was spent on developmental research.

However, the most debated question has been whether these total levels are adequate. Table 15.9 presents data on Canada's GERD, over the 1971-1986 period. The statistics show a large increase in GERD in constant 1981 dollars from \$2,687 million in 1971 to \$5,074 million in 1986. However, GDP rose substantially as well. Hence GERD as a percentage of GDP rose only from 1.32 per cent to about 1.36 per cent.

Critics point to *GERD as a percentage of GDP* and suggest that 1.36 per cent is simply not high enough. This view finds support in comparisons with other countries. As Figure 15.2 indicates, Canada's ratio of GERD to GDP falls far below the other OECD countries. CHEF, for example, cites this comparison as justification for higher public funding of R&D.

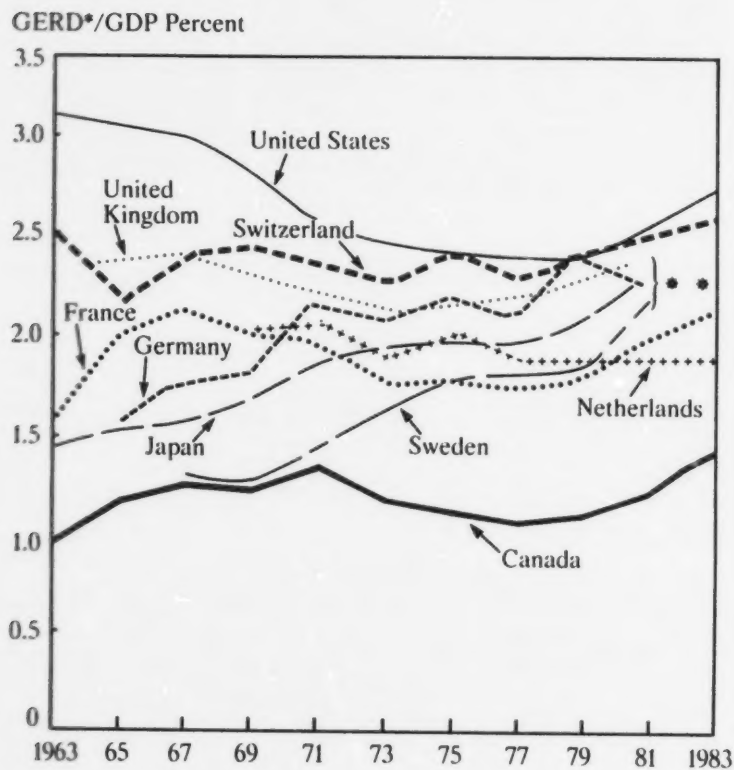
Table 15.9
Gross Domestic Expenditures on R&D in Current Dollars
In 1981 Dollars And In Percentages of the Gross Domestic Product
1971-1986

Year	GERD \$000,000	GDP \$000,000	GERD/GDP %	GERD in 1981 Dollars ¹ \$000,000
1971	1,287	97,290	1.32	2,687
1972	1,357	108,629	1.25	2,698
1973	1,455	127,372	1.14	2,684
1974	1,671	152,111	1.10	2,675
1975	1,882	171,540	1.10	2,724
1976	2,050	197,924	1.04	2,728
1977	2,299	217,879	1.06	2,874
1978	2,590	241,604	1.07	3,084
1979	3,006	276,096	1.09	3,298
1980	4,344	309,891	1.13	3,492
1981	3,946	355,994	1.22	3,946
1982	5,101	374,750	1.36	4,267
1983	5,420	405,425	1.34	4,324
1984	5,966	443,327	1.35	4,616
1985p	6,597	476,361	1.38	4,958
1986p	6,901	509,000	1.36	5,074

1. GERD in current dollars deflated by the GDP implicit price index.

Source: Statistics Canada, Resources for Research and Development in Canada, 1984, Catalogue No. 88-203.

Figure 15.2
Proportion of Gross Domestic Product Devoted to R&D
for Selected OECD Countries



* Gross domestic expenditure on research and development, including Natural Sciences, Engineering, Social Sciences, and Humanities except for Sweden, and 1963-69 for Canada for which only NSE is reported.

** Data not available for 1983.

Source: Corporate-Higher Education Forum. *Spending Smarter*.
 Montreal: Corporate-Higher Education Forum, 1985, p. 28.

Numerous reports by organizations in both the public and the private sectors amply document Canada's comparatively low R&D investment levels. At less than 1.5 per cent of gross domestic product, our spending levels have been consistently lower than the levels in other developed countries. Furthermore, our level of R&D investment has tended to remain flat—despite repeated and continuing exhortation to increase it (CHEF 1985, pp. 27-28).

Edwin Mansfield examined this question in a background study for the Royal Commission on the Economic Union and Development Prospects for Canada. Mansfield noted that:

Nothing seems to have stirred as much controversy as the apparently low level of research and development expenditures in Canada. The Minister of State for Science and Technology (MOSST) in 1978 announced a national priority of achieving a ratio of R&D expenditures to gross domestic product of 1.5 per cent. This target was reiterated in 1980 and again in 1981 (Mansfield 1985, pp. 92-93).

However, Mansfield presented a number of reasons why this ratio is not appropriate as an indication of whether our total GERD is adequate. Canada benefits from foreign R&D, particularly through subsidiaries of MNEs. Mansfield quotes the work of other researchers to support this view:

As Palda and Pazderka (1982) and others point out, the relatively low level of R&D spending in Canada may be the result of the structure of Canadian industry. Since over half of its manufacturing industry is foreign owned (Rugman 1983), Canada benefits from a large amount of R&D performed outside Canada. As indicated in one MOSST (Canada 1978) paper:

Canada's domestically conducted R&D does not begin to approximate its total source of new technology, inasmuch as, being largely foreign-owned, Canadian industry has ready access to R&D imported from foreign parent companies. Significantly, much of this imported R&D enters the country without being financially recorded. . . .

According to estimates by MOSST, such "invisible" R&D imports in 1975 totalled more than \$500 million (Mansfield 1985, p. 92-93).

Specific Programs to Support R&D

Many government programs consider R&D, innovation, and the adoption of new technology as important criteria in deciding on a corporation's application for financial assistance. Several government programs have been created expressly to stimulate such activity. We now turn our attention to these programs.

In 1977, the Enterprise Development Program (EDP) was created by the federal government.

The objective of EDP subsidies is to enhance the international competitiveness and productivity performance of Canada's secondary industry, and their formal focus is mainly on small and medium-sized firms. Subsidies to small firms may represent up to 75 per cent of project costs, while subsidies to larger firms may account for 50 per cent (Economic Council of Canada 1983, p. 66).

The Industrial Research Assistance Program (IRAP), established in 1962, has been administered by the National Research Council. It focuses on salaries of research workers hired by private corporations to undertake R&D projects. Usually, it pays 50 per cent of a project's costs.

The objective of the program is to increase the calibre and scope of industrial research in Canada in situations where it leads to high business effectiveness with economic and/or social benefit to Canada.

This objective will be pursued by providing financial support for approved research workers engaged in approved industrial research projects of high technical merit showing prospects for a high return and with good business plans for achieving success. Such projects should:

- a) be aimed at innovative products or processes realistic to the company and of significant need or benefit for the economic and/or social life of Canada, and might particularly
- b) relate to research which, in relation to the company's resources, is an unusually high risk, expensive, or

longer range area, but where the potential benefits nevertheless appear large and/or

- c) be designed to increase Canada's competitiveness in world trade in realistic situations by strengthening a necessary technological base in a company's present field or in an appropriate new field, and/or
- d) encourage participation by government and university scientists in industrial activities, and/or
- e) assist the attainment of the objectives of the Canadian Government's industrial strategy as it may be formulated from time to time (Economic Council of Canada 1983, p. 71).

The Program for Industry/Laboratory Projects (PILP), which began in 1975, also provides the financial and technical assistance of the National Research Council to private firms undertaking research. Project proposals are judged on the following criteria: economic benefit to Canada; good potential market; qualified company management; enhancement of company R&D capability; level of company commitment; level of National Research Council of Canada involvement in proposal; social benefits to Canada; level of technical and commercial risk; coincidence with national priorities; advancement of scientific knowledge; and contribution to regional development (Economic Council of Canada 1983, p. 71).

The Defence Industry Productivity Program (DIPP) concerns military equipment for which technology is of overriding importance. To be able to sell their products, Canadian manufacturers must be at the forefront of technological advances. Recognizing this, the Canadian government instituted the DIPP in 1959 as a mechanism for assisting the R&D of corporations that manufacture military equipment.

The objective of DIPP is to develop and sustain the technological capability of the Canadian defence industry for the purpose of generating economically viable defence exports and related civil exports arising from that capability:

- (a) by supporting selected development projects;

- (b) by paying one half of the cost of acquisition of new advanced equipment required for plant modernization; and
- (c) by supporting the establishment of production capability and qualified sources for production of component parts and materials.

In keeping with the Department's roles of promoting export sales and viable industrial growth and efficiency, DIPP resources are directed to projects that serve the objectives of international defence development and production sharing arrangements and, in addition, to projects that support industry sector strategic objectives and maximize the potential economic return on the resources employed.

Where an immediate market is apparent, the applicable ratio of sales to program support should be 10 to 20 times of the Crown investment. The Canadian content of the expected product sales is the determining factor in the application of this ratio. Where the Canadian content is less than 50 per cent, the ratio should approach 20 to 1: where the Canadian content is greater than 50 per cent the ratio may approach 10 to 1 (Economic Council of Canada 1983, p. 68).

The federal government and some provincial governments have also introduced special tax concessions to provide additional financial incentives for R&D. These concessions have been altered frequently. In Quebec, for example, a stock savings plan encourages individuals to purchase shares in corporations by providing special tax deductions and it pays part of the corporate costs of arranging for new stock issues.

Table 15.8 indicates that the proportion of GERD performed by the Canadian government is considerably higher than the government proportion in other OECD countries. Government contracting out, to foster technology development, has not occurred as extensively in Canada as in other industrialized countries. We should note that our private and academic sectors have become critical of government's ability to perform practical, in-house research. When government chooses to perform a substantial amount R&D activity itself, academics and businessmen regard it as important that "government research results find their way systematically and efficiently into the commercial sector" (CHEF 1985, p. 51). However, some private sector commentators consider that "any attempt, at present, to take the results of government-conducted research with a

view to commercializing them is a fool's errand" (CHEF 1985, p. 51). Government departments do not have the same propensity as private enterprise for risk-taking and this creates an innovation gap between government and business. Furthermore, as, the 1985 Task Force on Program Review claims, contracting out policies result in productivity improvements attributable to competitive pressure, economies of scale, greater managerial flexibility, lower labour costs, use of productivity incentives, cost-conscious decision-making, and clear objectives and priorities (Canada, Task Force on Program Review 1985, p. 126).

The Canadian Manufacturers Association (CMA) claimed in 1986 that increased contracting out policies "can save money and reduce the \$1,529 million governments currently spend on government R&D" (1986, p. 7).

The Task Force on Federal Policies and Programs for Technology Development (1984) also emphasized this issue, referring to "a growing atmosphere of irrelevance and an excessively bureaucratic management style." The task force report strongly recommended "that a review of all federal laboratories be carried out, with each laboratory being required to demonstrate to a designated central agency its relevance and usefulness" (pp. 25-33).

Retraining and Skill Development

In a 1985 book that evaluated a wide range of Canadian industrial policies, Richard Bird emphasized that adjustment assistance "is perhaps the most important of all, although it has been neglected not just by advocates of industrial strategy but also by most economists as well as government at all levels" (Bird 1985, p. 91). Bird concluded that:

Growth means change, change requires adjustment, and adjustment is always uncomfortable and costly for those directly affected by it. In Canada, such people frequently turn to government for relief, and too often they receive it in the form of measures that block rather than assist change. Too seldom does government facilitate the transfer of resources — people and capital — out of dying industries into growing ones. Yet there can be no successful industrial policy without such adjustment, and there is, therefore, no role more important for government than the direction of aid to industries, firms, regions, and — above all — people in such a way as to facilitate adjustment. By this standard, Canada and Ontario — like most industrial economies (Lindbeck 1981) — are not doing well (Bird 1985, p. 91).

From this perspective, research and education policy are intimately linked in several ways with adjustment assistance, particularly retraining and skills development. The successful application of research and education policy will make traditional jobs obsolete, thereby directly increasing the need for retraining and skills development. As emphasized in Chapter XIII, the effectiveness of research and education policy will also depend on the existence of an adequate number of appropriately qualified personnel. Finally, in a democracy, an essential issue is the degree of political support for public funding of research and education policy. The attitude of the individual voter will depend on his or her expectation that retraining and skills development will be readily available if technological change does alter his or her job significantly.

The Canadian record in retraining and skills development includes many different programs, and it involves annual expenditures in excess of \$1 billion. In spite of these efforts, many observers share Richard Bird's judgment that "Canada and Ontario—like most industrial economies—are not doing well." (Bird 1985, p. 91) Let us first note the facts of the Canadian record, and then consider more closely some of the criticisms.

Ronald Saunders (1984) has recently compiled the information reported in Table 15.10, in which he presents the names of the federal government's current programs and the names of prior programs which they have replaced. In each case, Saunders describes briefly the benefits that the current program provides. As Table 15.10 indicates, many federal programs contain provisions that also help workers involved in retraining and skills development. The Industry and Labour Adjustment Program (ILAP), for example, provides living allowances for workers in specific declining industries who are enrolled in retraining programs.

In Table 15.11, Saunders presents the federal government expenditures on programs targeted specifically at training, retraining, and skills development.

For each year, from 1975-1976 until 1982-1983, Saunders also presents data in Table 15.12 on the number of trainees who have started in these programs.

Provincial Programs

In addition to these federal programs, each province has established programs to provide its residents with extra public funding for retraining and skills development. The authors have not yet found a summary aggregation of provincial expenditures. But the following description was issued in 1985 by the provincial education ministers:

Table 15.10
Federal Adjustment Assistance, 1983

1. Type of Service	Placement, counselling and information
Program Name	Canadian Employment Centres (CECs)
Program Replaced	National Employment Service; Canada Manpower Centres
Benefits	Services available to all workers and employers; workers collecting UI benefits must register
2. Type of Service	Compensation
Program Name	Labour Adjustment Benefits (Labs)
Program Replaced	Adjustment Assistance Benefits (AABs) (also called Pre-retirement Benefits)
Benefits	Weekly payments to older workers laid off from textiles and clothing industries (since 1971) and footwear and tanning industries (since 1978)
3. Type of Service	Graphic-mobility assistance
Program Name	Canada Manpower Mobility Program
Benefits	Reimbursement of part of relocation expenses and/or travel expenses for job search or for training not available in home area
4. Type of Service	Training-institutional
Program Name	National Institutional Training Program (NITP)
Program Replaced	Canada Manpower Training Program (Institutional Component) (CMTF)
Benefits	Skill training of various kinds in an education institution (usually provincial), plus living allowance
5. Type of Service	Training-institutional
Program Name	Skills Growth Fund
Benefits	Capital funding for facilities to train in "priority" (shortage) occupations

Table 15.10 (continued)

6. Type of Service	Training-industrial
Program Name	General Industrial Training (GIT)
Program Replaced	Canada Manpower Industrial Training Program (CMITP)
Benefits	Skill training on the job, plus wage subsidy (both subsidies go to employer)
7. Type of Service	Training-industrial
Program Name	Critical Trade Skills Training Initiative (CTST)
Benefits	Like GIT but specifically for highly skilled trades with labour shortages
8. Type of Service	Training-industrial
Program Name	Training allowance supplement for laid-off apprentices
Benefits	Supplements to UI benefits available to laid-off apprentices in critical occupations; training can continue with employer or in an institution
9. Type of Service	Mixed
Program Name	Industry and Labour Adjustment Program (ILAP)
Benefits	Aid to communities hard hit by large-scale layoffs. Measures include enhanced living allowances for workers in retraining; portable wage subsidies; enhanced mobility allowances; early retirement benefits; direct job creation (CEP); capital funding (interest-free loans) to firms

Source: Saunders, Ronald S. *Aid to Workers in Declining Industries*. Toronto: Ontario Economic Council, 1984, p. 24.

Table 15.11
Institutional and Industrial Training: Program Expenditures
(millions of dollars)

	1976/76	1976/77	1977/78	1978/79
Institutional training:				
Purchase expenditures	269.4	285.3	302.2	331.7
Allowances paid to trainees	186.3	200.2	190.8	117.0
Unemployment insurance	-	-	19.0	102.7
Subtotal	455.6	485.5	512.0	551.4
Industrial training	48.7	59.5	76.7	83.7
Critical trade skills	-	-	-	-
Training improvement program^a	2.3	2.7	2.5	2.3
Total	506.6	547.7	591.2	637.3
	1979/80	1980/81	1981/82	1982/83 ^b
Institutional training:				
Purchase expenditures	345.9	395.0	419.9	488.3
Allowances paid to trainees	84.2	103.6	105.7	113.3
Unemployment insurance	140.7	157.8	166.5	195.0
Subtotal	570.9	656.4	692.1	796.6
Industrial training	101.3	106.1	111.0	83.3
Critical trade skills	0.7	7.5	26.7	57.9
Training improvement program^a	0.1	-	-	-
Total	672.9	770.0	829.8	937.9

a. This program funded projects conducted by the provinces to improve the effectiveness and efficiency of training purchased by the federal government. It was terminated on March 31, 1979.

b. Figures for 1982/83 are allocations.

Source: Saunders 1984, p. 59.

Table 15.12
Institutional and Industrial Training:
Number of Trainees Started

	1975/76	1976/77	1977/78	1978/79
Institutional training	213,184	236,481	229,679	207,558
Industrial training	61,389	60,788	69,698	78,936
Critical trade skills	-	-	-	-
Total	274,573	297,269	299,377	286,494
	1979/80	1980/81	1981/82	1982/83 ^a
Institutional training	225,627	223,826	219,494	222,800
Industrial training	83,334	79,863	67,746	39,681
Critical trade skills	502	4,102	5,486	9,167
Total	309,463	307,791	292,726	271,648

a. Estimate

Note: Annual reports of Employment and Immigration Canada.
 Data for 1981/82 and 1982/83, not published at time of
 writing, were provided directly by EIC.

Source: Saunders 1984, p. 59.

Each province and territory has taken steps to ensure the relevance and adequacy of training programs in accordance with the needs and priorities of its region. Saskatchewan, for example, in 1983, embarked upon a comprehensive four-year plan to expand its technical-vocational training capacity. The plan calls for a \$25 million, state-of-the-art training institute in the northern region of the province, along with the expansion of capacity in high demand program areas in the existing provincial institutes. The plan has also seen major program development undertaken with extensive input from industry. All programs at the

new northern institute will be competency-based with computer-managed individualized progress.

Newfoundland's newly-created Department of Career Development and Advanced Studies recently released a White Paper on the reorganization of its technical and vocational institutes into a provincial college system. The proposed changes, to be implemented over three years, will see a substantial reduction in the volume of training in traditional trades, address the need to introduce new training courses which will better meet the labour market needs of the 1990s, and establish a progressive retraining system for instructional personnel.

British Columbia has introduced a new approach to the delivery of vocational training, the Training Access (TRAC) Program. It is self-paced and competency-based. A major feature is a guarantee of provincial standards.

In Manitoba, major changes in the organization and operation of community colleges are being made in order to allow the institutions to respond more effectively and make more efficient use of available resources. For example, admissions and instructional programs are being altered to increase the capacity and effectiveness of institutions through the introduction of competency-based entry, instruction and exit. All programs are now subject to regular evaluation, which allows for the replacement of outdated programs by new programs more relevant to current needs. Student support services are also being restructured in order to improve retention and success rates, especially for disadvantaged students.

The Northwest Territories, with its widely scattered, isolated communities, is now in the early stages of introducing an Arctic College system, aimed at serving all communities regardless of size, location, or educational needs. Geographical constraints, cultural and linguistic diversity, and regional economic demands dictate that the college be largely field-based and that it respond flexibly to the need for regional specialization. A prime example of such flexibility is the training of teachers fluent in both English and the specific native language of a region or community. Wherever possible, college services are offered through existing facilities made available through government and the private sector.

To keep pace with changing technology and to facilitate the introduction of training programs that respond quickly to labour market requirements, New

Brunswick has adopted a College Orientation Program whereby, in addition to a common core of programs, each college is given a specific orientation and is expected to provide a leadership role for the rest of the province in its area of specialization.

Provincial departments and community colleges rely on the active involvement of local community resource persons as well as business and industry representatives for the identification of program and service needs. In Ontario, a network of Community Industrial Training Committees has been created to provide advice to all parties involved in training for the labour force. The voluntary membership of these Committees includes representatives from business, industry, management and labour (Canada, Council of Ministers of Education 1985, pp. 6-7).

In September 1986, Ontario's Minister of Skills Development announced a new \$100 million-a-year retraining program that he predicted would help more than one million workers over the next five years. The government will pay for up to 80 per cent of the costs of retraining, including both tuition and lost wages when workers have to attend formal educational institutions.

The five-part program consists of:

- \$15 million for a training consulting service for businesses available . . . at ministry offices at 30 locations in Ontario, to prescribe the type of training programs needed;
- \$43 million from Ontario Skills in incentives to support employers' costs in running training programs based on the result of consultation, to encourage more "employer-based" training;
- \$4 million for an updating program for individually skilled tradespeople, who can apply for the program (which began January 1, 1987) at the apprenticeship offices of the ministry of skills development;
- \$32 million in measures to ensure broader access to training programs, including day care, transportation and accommodation subsidies and a "major commitment" to promote literacy;

- \$6 million for an Institute for Skills Training to ensure high quality of training programs (*Toronto Star*, September 5, 1986, p. A1).

Recent Shifts in Retraining

In examining the Canadian record, one is struck by a shift in the nature and purpose of retraining and skills development. This shift occurred because of substantial criticism of the 1960-1982 practices. In Table 15.10, we saw how this shift resulted in the elimination of four federal programs and their replacement with four new programs. And the September 1986 announcement of the Ontario government also reflected this shift.

This shift has two related aspects. First, retraining and skills development are moving away from formal instruction within educational institutions and increasingly towards practical, on-the-job training within corporations. Second, the purpose is shifting from the teaching of general education courses towards the development of the more sophisticated skills needed in our new high-tech economy.

The MacDonald Royal Commission applauded these two aspects of the recent changes. Its final report stated:

Governments have tended to provide most of their employment-training assistance through institutional training programs based primarily in Colleges d'enseignement general et professionnel (CEGEPs) and community colleges. Most such training, however, is provided on the job without government support. The costs of this type of training are largely shared by employers, in the form of temporary foregone production, and by their employees, in the form of temporarily foregone wages. What, then, is the appropriate balance between on-the-job and institutional training? No unequivocal answer to this question is possible, but a case can be made for some movement toward on-the-job training and away from institutional programs. Fortunately federal policy is already progressing in that direction.

Under the AOTA, it provided courses of training primarily for those Canadians who had discontinued formal schooling for at least 12 months; these courses, which were provided in provincial institutions, mainly community colleges, were limited to a year's duration. After 1974, each province was given a guaranteed minimum of funds for such training, indexed to the Statistics Canada Education Price Index. Under the National Training Act, the old

Canada Manpower Training Program (CMTP) was replaced by a new National Training Program (NTP) to offer more flexible institutional training.

Until the inauguration of the NTP in 1982, the federal response to criticism of CMTP took two main forms. A decision was taken to reduce the proportion of CMTP trainees enrolled in the low-level Basic Training for Skills Development (BTSD) courses. In addition, the number of CMTP trainees relative to trainees in on-the-job industrial training programs was steadily reduced. Thus there was a shift of resources toward higher-level skill development and from institutional to industrial training (MacDonald Commission Report).

In the 1980s, several major studies have been undertaken to recommend improvements in these programs. Of particular importance have been the following:

- the Dodge Report, *Labor Market Development in the 1980s*
- the Allmand Report, written by the Parliamentary Task Force on Employment Opportunities for the 1980s
- the Economic Council of Canada Report, *In Short Supply*
- The CEIC's Skill Development Leave Task Force Report, *Learning a Living in Canada*.

In general, these four reports advocated the kind of shift in structure and purpose that is now occurring and that we have already discussed. Beyond these general changes, their recommendations also dealt with dozens of specific aspects of particular programs. For example, the Allmand Report made 186 policy recommendations.

These studies of the Canadian labour market demonstrate the large degree of uncertainty surrounding public policies for education, retraining, and skills development. It is by no means clear which policies are the most effective. One cannot present recommendations with much certainty or confidence. In view of this, what we can emphasize is the need for continual evaluation of particular features of these programs on the basis of actual experience. Once again, we see the need for corporate involvement in this aspect of research and education policy.

Writing a one-time list of policy recommendations would be only a partial achievement: only one step in a continuing journey. The really important questions concern the process for policy evaluation

and the process for participation in future policy modifications. How can corporations decide whether particular program features are optimal? How can corporations become aware of alternative policy options? How can corporations most usefully channel their judgments into the process of future policy modifications?

Conclusion

Throughout this book, we have seen the importance for the information technology sector—and for high-tech in general—of education and research policies. There is evidence that the lack of suitably-qualified personnel can slow the development and diffusion of new technology. The process of technological change involves the generation of new skill requirements and the elimination of others; and it is through appropriate education policies that our labour force will acquire the ability to adapt to these changes. For a number of reasons, governments today have an important role to play in assisting the research process both within educational institutions and also within corporations. Of particular significance is the development of research linkages between universities and corporations.

We can point to many indications that Canadian governments have responded well to these new challenges. However, we can also see severe shortcomings. We believe that Canadian governments—as well as universities and corporations—can learn from the experiences of other nations. It is in this belief that we have drawn attention to a variety of foreign experiences. Of significance is our conclusion that the new world economy will be a place of continual change, based upon ever-increasing knowledge. Our specific policy objectives will not be immutable. Rather, we shall have to adjust education and research policies in response to changes in the economic environment. From this perspective, the process of policy formation is seen as important, quite apart from the content of particular current policies.

Chapter XVI

High-Tech in a New World Economy: Concluding Comments

Introduction

In summarizing the many issues and analyses of this book, it will be helpful to focus on three concepts that are closely related: integration, change, and knowledge. Integration is the result of a variety of changes, and is itself the cause of further changes. Knowledge involves an understanding of changes—past, present, and future—together with insights as to how to use this understanding in economic activities. Change includes adjustment to the new circumstances created by various kinds of integration and by advances in knowledge.

Integration

This book has described a new world economy in which a number of historical barriers and divisions are disappearing very quickly. The economic integration of separate political entities is clearly a significant development. Journalistic commentaries emphasize the new political agreements that, in several ways, tend to erase political boundaries. In our post-1945 world, General Agreement on Tariffs and Trade negotiations have reduced tariffs and have sought to reduce other trade barriers. The European Economic Community has removed the political boundaries within Europe for a number of purposes. For Canada, the elimination of the Foreign Investment

Review Agency, and its replacement with Investment Canada, has marked a more open acceptance of foreign investment. Recent Canada-U.S. negotiations have sought additional areas within which bilateral trade may occur more freely. In considering this economic integration of separate political entities, this book has emphasized economic forces rather than political agreements.

A key role in this economic integration is being played by multinational enterprises (MNEs). Apart from trade in agricultural products, a large portion of international trade occurs within MNEs. The networks of parents and subsidiaries have become mechanisms for rapidly transferring production technology as well as goods and services. The practice of allocating global missions or product mandates among the subsidiaries of MNEs has enabled MNEs to achieve economies of specialization and scale—and the gains from trade—quite apart from political agreements to reduce trade barriers. This perspective also sees international trade and investment as complements rather than substitutes, and so it leads to a number of insights concerning the determinants of investment location. The establishment of subsidiaries within large numbers of political entities has enabled MNEs to apply for subsidies from each government and to apply for preferential treatment in government procurement. That is, MNEs have become local residents of many countries, and are therefore able to avoid non-tariff barriers that might otherwise distort trade patterns. Regulations designed to assist domestic firms to the detriment of foreign firms can often be complied with by the local subsidiary of the MNE. Within federal states, where state or provincial governments have their own separate subsidies, procurement preferences, and regulations, the national corporation with branches in each state or province can avoid these trade barriers in the same manner as the MNE can on the international scene. In these ways, apart from new political agreements, closer economic integration is developing among separate political entities.

Our study of information technology led us to realize that product lines previously manufactured and sold separately are now being integrated as a package sale. The creation of solutions involves elements from each of office equipment, telecommunications, robotics, and specialized business consulting. The creation of solutions also involves a greater emphasis on information and knowledge, and this means that the sale involves services such as software and consulting as well as physical goods. We believe that this integration of product lines, with a greater emphasis on information, knowledge and services, is a feature common in other high-tech sectors as well.

This trend towards the integration of product lines, and the integration of goods and services has many important implications for the gathering and classification of data as well as for policy

formulation. Traditional data classifications are becoming less useful, and it has become necessary to develop new classifications. For example, Statistics Canada recently revised its definition of high-tech goods, but even the new definition fails to cover the high-tech components of traditional economic activities. Creative work must be done to develop new classifications that can reflect the recent integration of product lines. The growing role of services within the sales package adds enormously to the difficulty of this task.

This integration of production and sales activities has important implications for barriers to trade and for new political agreements to reduce those barriers. An obstacle to trade in one element of the sales package can be an obstacle to the sale of the entire package. This emphasizes the need to deal with services in forthcoming trade negotiations—a barrier to international trade in services can be a barrier to international trade in goods. The specialized knowledge that is becoming a greater part of the package sale has added to the importance of the protection of intellectual property. From this perspective, one can appreciate the recent GATT decision to focus on trade in services and the protection of intellectual property in the forthcoming GATT round of negotiations. This perspective also emphasizes the importance of the right to establish a commercial presence in countries where a firm wishes to do business. Investment barriers can be effective trade barriers. Finally, the integration of product lines and of goods and services will facilitate domestic preferences in government purchases and will make new international procurement codes more difficult to enforce.

Integration is also occurring in the activities between customers and suppliers. Increasingly, solution selling is a tailor-made package developed in accordance with the particular needs of the customer. This means that the supplier's employee must thoroughly understand the customer's needs and production technology. In this sense, the supplier's employee is an employee of the customer. The reverse is also true. The supplier must constantly innovate to maintain its market position. New products and new processes are developed in accordance with the changing needs of the customer. In this sense, the customer has become an integral part of the supplier's innovation process. This relationship can be seen clearly, for example, in the supply of military systems. Development of new technology is essential in the international military race. Firms that supply military equipment become intimately involved in the needs of the military, and the innovation process is motivated by those needs. From the perspective of economic analysis, the traditional divisions between suppliers and customers are disappearing.

This integration adds a new perspective to the theory of the firm. It suggests that the size and function of the firm may be increasingly

flexible. Subcontracting among firms may become more prevalent. Shareholders and employees may have greater freedom in choosing the scale of their firm's activities, since the lines that divide firms are becoming less meaningful.

Finally, this integration of product lines, goods and services, and firms means that business consulting—or the creation and sale of specialized knowledge—may play a greater role in economic activities. Our study of the information technology sector leads us to believe that firms in this sector are particularly well suited to take advantage of this development. They are most familiar with the process of combining the various elements of a sales package in a new and creative solution geared to the needs of each customer. While accounting firms have traditionally supplied a large segment of the business consulting market, the information technology firms are likely to become the dominant participants over the coming years.

A final area of integration that also has important ramifications concerns linkages between governments, educational institutions, and corporations. For a number of reasons, education and research deserve more government funding than they have received in the past. The greater reliance on government assistance is part of this integration, with governments increasingly concerned about how public funds are being used. Society's growing dependence on education and research as determinants of growth, prosperity, and jobs also means that the success of education and research has become a matter of major public concern. On a practical level, certain types of education, particularly retraining, will be provided within corporations rather than within formal educational institutions. Similarly, it can be argued that certain types of research, geared to commercial applicability, can best be conducted through joint university-corporate projects. Recent policy shifts by Canadian governments, recognizing the benefits society can gain, are attempting to foster this integration.

Change

The various types of integration have developed as responses to particular changes in the economic environment. Integration itself is leading to additional changes, and many of these are part of the preceding discussion. Besides the implications already discussed, several additional implications of change deserve a place in our concluding remarks.

For the information technology sector, change is a continuous, ever-present feature. For many information technology firms, sales and profitability depend on their ability to create and sell new solutions. In this sense, many information technology firms sell

change. If products and technology were to remain unchanged, information technology firms would encounter a precipitous drop in sales and profitability. Consequently, for the information technology sector, a central focus of public policy is the facilitation of change throughout the entire range of economic activities. The success of our information technology sector will depend on the degree to which potential customers in traditional activities can be convinced to adopt new and innovative solutions.

This perspective emphasizes the significance of the diffusion of new technology, with individual modifications to suit the needs of each customer. Economic activities within agriculture and natural resources, for example, can be participants in change, perhaps to a degree where they even deserve the appellation "high-tech". Once again, we see that to refer to only specific sectors as high-tech, such as information technology, is to miss an essential aspect of high-tech. To rely on statistics classifications where only specific sectors are included as high-tech is to draw inappropriate inferences. With a narrow view of high-tech, one may advocate public policy that seeks to assist new venture capital firms within those specific sectors. With a broader appreciation for the concept of technological change, one is likely to advocate public policy that seeks to assist technology diffusion throughout the entire range of economic activities. Traditional industries, having used innovation to improve their competitiveness, may well contribute to productivity growth, as much as, or more than new venture capital firms.

An important aspect of technological change is that it tends to be cumulative. An entrepreneurial culture can develop in a certain geographical area or within a certain population group. A willingness—even an eagerness—to apply new solutions in the improvement of products and production processes can become part of a certain business atmosphere. Changes within one firm may be copied readily by other firms that are in the same geographical area. Employees may be hired away from firms that are at the leading edge of innovation. A large population inevitably has many potential customers, and this means that a firm whose existence depends upon finding new solutions for its customers will be attracted to a large city. The supplier-customer integration discussed earlier supports the rationale for locating near as many potential suppliers and customers as possible. All of these geographical aspects of change may tend to exacerbate regional economic disparities.

The importance of change draws attention to the question of organizational processes that can facilitate technological change. Our discussion of Japan has noted the belief of some observers that the nature of labour-management relationships can have a significant impact on an organization's success in innovation. Processes that

directly involve each employee in group decisions about quality improvements and new production technology may facilitate change. There may be a connection between these relationships and processes, and the size of an organization. In a small organization such an approach may be established more easily, and it may even develop automatically. A large corporation may have to create an atmosphere conducive to change through deliberate policies. Recent literature describes "intrapreneurship" as a set of policies that may facilitate innovation within large corporations. For most nations today, government bureaucracies have become huge, and they form a major component of aggregate economic activity. Consequently, this subject is of particular importance when we consider the need to innovate within government administrations. Increasingly, the relationships and processes that may facilitate technological change will be of public concern, since they will be a major determinant of a nation's international competitiveness.

Knowledge

The creation and application of new knowledge are the central driving forces within both integration and change. We have presented a broad view of knowledge that includes education, retraining, and research. This broad view emphasizes not only technical knowledge concerning products and production processes, but also the understanding of human nature in regard to such matters as employment motivation and consumer purchases. In our new world of integration and change, knowledge in both sciences and humanities are important determinants of a society's international competitiveness.

Both the process of technological change and the trend towards greater integration are continually opening up new commercial opportunities. They are also constantly eliminating certain economic activities and the accompanying jobs and incomes. Whether a society will be hurt by these developments or will take advantage of them, will depend largely on the quality of its education and research. It may be well to repeat some comments about this from Chapter I.

We have emphasized that we must modify the traditional dichotomy of capital *vs.* labour. Traditionally, trade analysts labelled some products as capital-intensive and others as labour intensive. A nation's comparative advantage would be determined by the relationship between its stock of capital and its stock of labour, and by the consequent relationship between its cost of capital and its average wage rate.

In today's new world economy, however, capital is embodied in labour through education and skills training to significantly varying degrees. It is necessary to distinguish between those goods and

services where labour is largely unskilled, and those goods and services where the labour is, in effect, capital intensive. It is not appropriate to think of comparative advantage for high-tech sectors as a whole—as in much popular commentary about trade and investment today. Rather, a nation's comparative advantage depends on the particular type of labour used in a particular type of high-tech good or service. We can expect that Canada will export some high-tech goods and services and at the same time will import other high-tech goods and services.

This emphasis on education and research is important from the dynamic perspective of technological progress. That is, technological progress depends on capital, embodied within labour. This perspective on international comparative advantage emphasizes the transitory or temporary nature of this advantage. It emphasizes that job descriptions and occupational categories will be continually changing—as will the mix of high-tech goods and services that a nation imports and exports. It suggests that new "market niches" will continually open up for firms that develop specialized advantages.

Throughout the world, the creation and diffusion of new technology are now being perceived as the foundation for future economic growth and prosperity. Less developed nations are quickly adopting technologies that were originally created in the advanced economies of Western Europe and North America. This technology transfer has altered traditional patterns of comparative advantage and international trade. Meanwhile, the advanced economies have become increasingly concerned about their ability to innovate. This race for more efficient technology has become a major determinant of international competitiveness. As participants in this race, individuals and corporations now look to their governments for public policies to help them to win. For many societies, the ability of government to engineer a comparative advantage is of paramount concern.

The role of labour qualifications as a determinant of corporate location decisions is particularly important. High-tech includes many occupations, requiring different levels of education and skills and paying different levels of wages. A society wanting to attract the high-tech activities that offer high wages must develop the corresponding levels of education and skills. Labour is not homogeneous. A society that ignores this relationship will relegate its citizens to the lower end of the job scale within our new world economy.

Canada, in that new world economy, will experience constant change. To retain the best jobs and highest wages, we must continually re-educate and retrain our workforce. Corporations will find continually that their sales mix will be changing, with new

products and new services being combined to create new solutions. Education and research will enable these corporations to retain a position in the lead of the technological race. From this perspective, education and research can be seen as the central mechanisms for creative adjustment in an ever-changing world economy. They will form the cornerstones of future Canadian competitiveness.

We have considered a number of indicators that suggest Canadian governments have been successful in fostering education and research. But we have also noted some disquieting concerns. Our emphasis is on the need to evaluate continually our education and research.

Concluding Comments

Integration, change and knowledge are related perspectives from which we can view our new world economy. They are three perspectives that we feel are helpful in the development and evaluation of contemporary public policies.

To what degree will Canada be a successful participant in the new integrated world of continual change? How well can we Canadians apply new knowledge to improve our international competitiveness and to adjust to new economic circumstances?

The keys to answering these questions will be found in the quality of our education and research.

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Glossary

Absolute Advantage:

A country is said to have an absolute advantage over another in the production of a particular good if it can produce that good using smaller quantities of resources than can the other country.

Comparative Advantage:

A country is said to have a comparative advantage over another in the production of a particular good relative to the other goods it can produce if it produces that good least inefficiently compared with the other country. A country's comparative advantage rather than absolute advantage determines the most efficient patterns of production. For instance, a country can gain by importing a certain good even if it produces this good more efficiently than it can be produced abroad if the country is even more efficient at producing the goods it produces in exchange.

Concentration of industry:

The share of the industry's total output supplied by some given number (usually four) of its largest firms.

Concentration ratio

Percentage of an industry's output produced by its four largest firms. This indicator is used to measure the degree to which the industry is dominated by large firms.

Economies of scale:

Savings acquired through increases in quantities produced. Because of increasing return to scale, a business enterprise is able, for instance, to more than double its quantity of output by doubling input quantities.

Economies of scope:

Savings acquired through simultaneous production of many different products.

Export orientation:

Represents the value of exports as a percentage of domestic shipments.

Externalities:

The result of activities that cause incidental benefits or damages to others with no corresponding compensation provided to or paid by those who generate the externality.

Import orientation:

Represents the value of imports as a percentage of domestic shipments minus exports plus imports.

Innovation:

Refers to a new product, process, or idea that is put into practical use - for instance, integrated into the existing production framework of the firm.

Intermediate good:

A good that is bought for resale or for use in producing another good.

Invention:

The act of generating a new idea, product, or process.

Labour productivity:

A measure of total output divided by the amount of labour used to produce it.

Multinational enterprise:

Corporations whose production activities occur in a number of different countries.

Patent:

A temporary grant of monopoly rights over an innovation.

Productivity:

The amount of output produced by unit of input.

Structural unemployment:

Refers to workers who have lost their jobs because they have been displaced by automation, because their skills are no longer in demand, or for similar reasons.

Value-added:

The value added by a company is its revenue from selling a product minus the amounts paid for goods and services purchased from other firms.

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David W. Conklin
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